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Medical Error and Harm

Coping With the Psychological Impact of Medical Errors: Some Practical Strategies, *L. Hawryluck, R. Styra*

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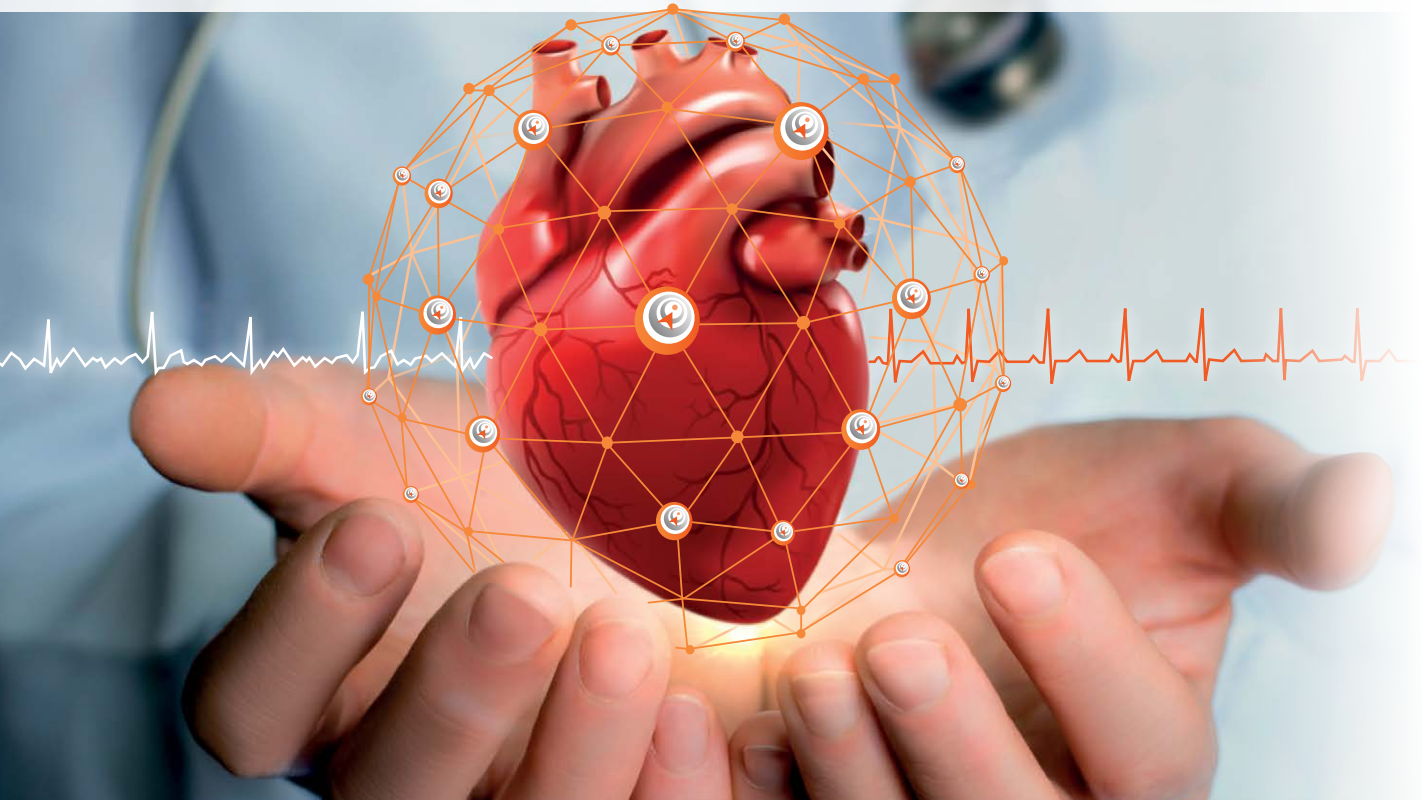

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1 Summary of Rapibloc® Product Characteristics, current version. – **2** Hindriks G., et al. 2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association of Cardio-Thoracic Surgery (EACTS). European Heart Journal (2020) 00, 1-126. – **3** Shibata et al. Direct Effects of Esmolol and Landiolol on Cardiac Function, Coronary Vasoactivity, and Ventricular Electrophysiology in Guinea-Pig Hearts. J Pharmacol Sci 118, 255 – 265 (2012). – **4** Yokoyama H. (2016) Stabilization in Off-Pump Coronary Artety Bypass. Springer Tokyo Heidelberg New York Dordrecht London © Springer Japan. – **5** European Heart Journal Supplements (2018) 20 (Supplement A), A1-A24. – **6** Nasrollahi-Shirazi S et al. Comparison of the b-adrenergic receptor antagonists landiolol and esmolol: receptor selectivity, partial agonism, and pharmacochaperoning actions. J Pharmacol Exp Ther 2016; 359:73–81

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Medical Error and Harm

Patients in the intensive care unit generally have complex healthcare issues with underlying comorbidities and organ dysfunction. They are thus more vulnerable to medical errors. Often, the treatment of these patients requires the use of interventions that could potentially result in adverse events, errors and harm. While critical care guidelines provide the necessary recommendations to ensure these errors and events remain at a minimum, the complexity of care and severity of illnesses in the ICU make this a high-risk environment.

In our latest cover story, **Medical Error and Harm**, our contributors talk about medical errors, adverse events and patient safety in the intensive care unit. They provide an overview of the prevalence of medical errors in the ICU, the types and frequency, and causes and risk factors associated with these errors and strategies to prevent them from occurring. They also discuss common but preventable harms in the ICU and how the safety of critically ill patients can be improved.

Laura Hawryluck and Rima Styra discuss practical steps and strategies to help healthcare workers cope with the psychological effects of being involved in an error event. Khara Sauro and Henry Stelfox explore trends in adverse events in ICUs and how evidence about the nature, preventability and predictability of these events can be used to improve patient safety in ICUs.

Irene Gabiña, Sonia Martínez, and Federico Vidal highlight the importance of transmission of information in the ICU and how it can play a decisive role in the safe care of the critical patient. Jorge López-Fermín, Diego Escarramán-Martínez, Raymundo Flores Ramírez and co-authors discuss some of the most common errors in the ICU and provide an overview of situations in which, sometimes, doing less is better for the patients.

Robert Shu lman provides an overview of the prevalence and impact of medication errors and the processes that could help reduce their incidence. Fredrik Olsen and Ashish Khanna talk about postoperative hypotension that is often unrecognised with intermittent spot check-based monitoring and provide a future outlook that may see a continuum of connected care via ongoing monitoring across the perioperative period.

Marian Altman and Debbie Brinker provide a nursing perspective on the quality of care in the ICU, the impact of the pandemic on patient safety and how nurse-driven initiatives and innovative solutions can help reduce harm to the patient. Aitor López-González, Irene Casas, and Elisabeth Esteban discuss the role of a mortality review committee as a tool to improve the quality of patient care based on reviews of deaths. Mariana Joya-Ramírez, Hassler Stefan Macías-Sánchez, Jorge Alberto Guevara-Díaz and co-authors highlight the importance of learning from errors and the need to restructure medical training programmes and systems to facilitate this goal.

As always, if you would like to get in touch, please email JLVincent@icu-management.org.

Jean-Louis Vincent

Jean-Louis Vincent
Editor-in-Chief
ICU Management & Practice
Professor
Department of Intensive Care
Erasme Hospital
Université libre de Bruxelles
Brussels, Belgium

JLVincent@icu-management.org

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Join our panellists on March 1 at 16:00 CET as they discuss the prevalence and types of medical errors in the ICU, the psychological impact of these errors, and strategies to prevent them and improve the safety of critically ill patients.

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Prof Jean-Louis Vincent
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Coping With the Psychological Impact of Medical Errors: Some Practical Strategies

Significant efforts have been made to make hospitals and ICUs as safe as possible. As healthcare workers (HCWs) try to get through this pandemic, the focus of this article is to explore practical steps to help these workers better cope with the psychological effects of being involved in an error event.

Laura Hawryluck
Professor
Critical Care Medicine
University of Toronto
Ontario, Canada

laura.hawryluck@uhn.ca

Rima Styra
Associate Professor of Psychiatry
University of Toronto
Ontario, Canada

rima.styra@uhn.ca

Introduction: Error Events, Causes and Psychological Effects

With all the efforts being made to make hospitals and ICUs as safe as possible, many layers of protection for patients now exist, yet adverse events and error events continue to happen. Some of these occur within hospital wards and can range from 'near miss' situations in which an event occurs yet harms do not reach the patient, to significant harms resulting in a need for rescue by admission to the ICU. Some occur within ICUs themselves. Some result in significant morbidity and some in mortality.

The frequency of medical errors varies depending on what is included within their classification. The worst result in significant morbidity and patient death. Within the ICU, medication errors are the most common (Foster et al. 2018; Escrivá et al. 2021; Escrivá et al. 2019; Piriou et al. 2017; Roumeliotis et al. 2020; Welters et al. 2011) and are related to dosage, timing, mode of delivery and medication interactions (Foster et al. 2018; Piriou et al. 2017; Roumeliotis et al. 2020). Other adverse events relate to the use of equipment, the development of nosocomial infections related to hand hygiene, insertion, care and duration of central lines, catheters, the inappropriate use of antibiotics, pressure sores, self-extubations, re-admissions within 48 hours, and the use of restraints to name but a few (Duarte et al. 2015; Welters et al. 2011). The current intense focus on patient safety within hospitals and healthcare settings with a concept of "zero preventable harms" has been widely espoused in particular since the Institute of Medicine's recommendations in their To Err is Human Report in 1999. With all the efforts being made to make hospitals and ICUs as safe as possible, many layers of protection for patients now exist before an error has the potential to both reach them and cause harm. In addition, research has identified many common sources of errors on a system wide level thus allowing individual hospitals and ICUs to learn from each other to improve their policies, processes and clinical practices. Yet even with all the safeguards that have been put in place, errors still occur, and though perhaps different in nature and scope than in the past, reaching zero preventable harms is still an elusive target.

In the ICU, the sheer acuity of illness, complex needs, knowledge of medications, knowledge of and skill with the use of new technologies, a lack of sufficient time between admissions and a failure to adequately transfer accountability for patient care within the ICU and upon discharge from specialised ICU care may contribute to errors and even worse outcomes for some patients (Parsons et al. 2021). While the reasons for the elusiveness in achieving zero preventable harms are many, perhaps the most obvious one is that healthcare workers (HCWs) are humans – people experiencing personal and professional life stressors, mental and physical health issues of their own, working in high stress environments and dealing with sleep deprivation especially if involved in shift work (Arimura et al. 2010). Unfortunately, the donning of scrubs and personal protective equipment (PPE) that transform ICU teams from humans into HCWs does not provide them with superpowers or cloaks of invincibility with respect to the commission of errors. Error events cause significant psychological distress in approximately 43% of HCWs (Seys et al. 2013).

The involvement in any error event is a very traumatising experience for HCWs (Kaur et al. 2019; Pratt and Jachna 2015; Seys et al. 2013) especially when they occur under emotionally demanding circumstances. How HCWs experience error events and their consequences may engage both physical and psychological reactions (Kaur et al. 2019; Seys et al. 2013). One qualitative study from France interviewed 20 ICU physicians and 20 nurses one month after an event and found 53.8% experienced feelings of guilt, 42.5% shame, 37.5% anxiety with rumination, 20% questioning their own professionalism and 32.5% loss of confidence (Laurent et al. 2014). The psychological impact may result in hypervigilance, a perceived need for self-verification

or oversight (Laurent et al. 2014). While hypervigilance and self-verification is an understandable reaction, if extreme it may be paralysing resulting in an inability to act or make decisions. Emotional distress may result in further mistakes, burnout, a reduction in work hours or departure from their profession (Mazurek et al. 2021). While talking with colleagues may help, some are not able to verbalise their experience and others feel that such support is not enough (Kaur et al. 2019; Laurent et al. 2014; Pratt and Jachna 2015). Some have found their coping with such events was improved by the disclosure and apology to patients, forgiveness and understanding of their own imperfection (Kaur et al. 2019; Plews-Ogan et al. 2016). Some used the error as an opportunity to develop skills and knowledge, participating in changes to prevent recurrences, teaching and helping others (Laurent et al. 2014; Plews-Ogan et al. 2016) while others have coped by minimising the error, avoidance and denying responsibility (Laurent et al. 2014). While the emotions and ways of coping may vary, what appears certain is that for many the psychological impact of involvement in medical error is significant (Kaur et al. 2019; Pratt and Jachna 2015; Seys et al. 2013) and may be long lasting (Laurent et al. 2014; Pratt and Jachna 2015), even career ending.

Effects of the Ongoing Pandemic

As ICUs around the world struggle during this ongoing COVID-19 pandemic with the sheer volume of patients and the severity of their illnesses, research has shown us the impact on their mental health is significant with symptoms of depression 30-57%, anxiety 46-67%, post-traumatic stress disorder 32-54% and burnout in over half of ICU team members (Azoulay et al. 2020a; Azoulay et al. 2020b; Styra et al. 2021). Many have not had time to tend to their own physical health (Styra et al. 2021). ICU teams are exhausted. As this pandemic continues, many ICUs are seeing HCW departures resulting in a greater workload for those who remain. Many ICU teams are being helped by physicians and nurses re-deployed from other fields and parts of the hospital. Such help is greatly appreciated yet requires varying levels and areas of oversight from ICU teams depending on pre-existing knowledge and skill sets—oversight needs that may change on a daily basis depending on who has been assigned to help. The oversight and help required from the ICU team to allow those who have come to help care for patients with life-threatening illnesses may not be achievable due to the volume of those in need. As the pandemic continues, the mental health of ICU team members and those re-deployed to help will likely deteriorate further. While not a lot of attention has been paid to this topic to date, though more research is underway, based on our current understanding of their causes, it is not hard to imagine that the frequency of error events will also increase as a consequence of the ravages of the pandemic.

> **“while the reasons for the elusiveness in achieving zero preventable harms are many, perhaps the most obvious one is that HCWs are humans”**

As the stressors of the COVID-19 pandemic to date only continue to increase with each variant and ‘wave’ of critically ill patients along with HCW attrition from illness, exhaustion and burnout, the likelihood of errors can be anticipated to increase (Mazurek et al. 2021). When combined with current stressors, the impact of error events, is likely to create an ever increasing rate of departures of HCWs from the ICU. As we all try to get through this pandemic, the focus of this article is therefore to explore practical steps to help HCWs better cope with the psychological effects of being involved in an error event.

Coping with Error Events: Practical Steps for HCWs and Organisations

Once the physical, visceral reaction to having made a mistake has passed, it is important to remember that with all the layers of safety measures in place today within an ICU, it is rare that an adverse event occurs and reaches a patient without breakdowns occurring at multiple levels. While an individual HCW may have been the ‘last peg’ in the safety measures breached, there are typically a series of mistakes and any one HCW is not likely to be solely responsible. Having a leadership role in a Rapid Response Team and having been involved in many critical incident debriefs as well as root cause analysis of critical error events, in our experiences the last peg in the safety breach is often initially unaware of all the previous failures in the safety net that aligned before the final mistake occurred and reached the patient. Assuming sole responsibility when this is not reflective of the actual situation because one is the most responsible physician (MRP), the bedside RN or patient’s RT is a self-sacrificing approach and a psychologically unhealthy way of addressing the event. Such an approach may result in more psychological distress than is warranted and may make recovery from the event more difficult. The sense of ultimate responsibility has been reinforced for years by hospital policies and practices that require the MRP to disclose the error to the patient and/or their family, bearing the brunt of the reaction when they receive little if any training in doing so and when events are usually multifactorial. In recognition of the true nature of error events, a better way forward would be to have more formalised training in timely disclosure of error events, a collaborative team approach to disclosure, what is known of its causes initially, what is being done to mitigate its effects on the patient, and how it will be explored to improve the quality of care in the future.

To really understand the psychological impact of an error event, we need to understand the concept of self-identity. For many HCWs, who have spent many years training, working increasingly long hours, who have volunteered for extra shifts, and stepped up to be re-deployed in this pandemic, their professional self-identity is deeply entwined with and even defines who they are as a person. For this reason, an error event that caused harm, for many, is an existential crisis. The emphasis on “zero preventable errors” goal and posted dates without/since last preventable error strategies to achieve these goals can exacerbate feelings of failure and cause HCWs to feel that they let their colleagues and organ-

isations down. Questioning of self-identity and self-perceptions of being a failure can be further exacerbated when disclosure is met by anger and threats of inter-personal violence and/or legal repercussions. While some have found support in being able to discuss the event with colleagues, many may not feel comfortable doing so (Laurent et al. 2014; Plews-Ogan et al. 2016) due to concerns of repercussions, perceptions of their mental health/coping skills in fields where pride is taken in being resilient or concerns about being judged if their working environment is new, not supportive in nature or if they have had other challenges in the past. Understanding the psychological impacts of an error event on both personal and professional identity is crucial to being able to recover from such events. Unfortunately HCWs are often perceived uni-dimensionally as professionals and the existence of a person inside the professional is either not acknowledged or not accorded the value needed to cope with these challenging events. No one goes to work in healthcare to cause harm to someone who is already struggling with illness. No one is infallible and if a HCW hasn't been involved in an error event in the past, they likely will be in the future. Keeping these two truths in mind is crucial to developing and maintaining a supportive work environment.

Another way of framing the psychological impact of error events is to return to Maslow's hierarchical needs which we used in a previous article (Hawryluck and Styra 2021). We discussed how the mental health, coping and resilience of HCWs in both personal and professional dimensions could be better supported during this current pandemic (Maslow 1954). Maslow described humans as having five hierarchical categories of values-based needs: physiological, safety, love and belonging, esteem and self-actualisation needs (Maslow 1954). In his theory, if the most basic physiological, safety, belonging and esteem needs are not met, psychological harms can ensue. Research has revealed the negative effects of error events on the HCWs own perceptions of self-worth. If not handled well by colleagues and team members, an error event can become a direct challenge to the need to belong and to be respected both as a professional and, again in view of how intertwined the concept of identity is for HCWs, as a person. A supportive environment for coping with an error event is therefore one in which it is consistently made clear that the HCWs involved have not lost value in the eyes of their colleagues and friends. A supportive environment is one that seeks not to further diminish the professional or the person by assigning blame, rather one that uses a spirit of inquiry to seek understanding of what occurred and seeks to then create preventative solutions.

> **"it is not hard to imagine that the frequency of medical errors will also increase as a consequence of the ravages of the pandemic"**

Critical incident debriefs reveal that one of the common causes of an error event in critical care is the loss of situational awareness (Schulz et al. 2016). Some of the most effective ways of helping a HCW understand an error event can be achieved through critical incident reviews and root cause analysis of the event (Mitchell and Schuster 2016; van der Starre et al. 2014). Both processes are commonly approached with some trepidation on the part of HCWs who are usually rarely exposed to them in training. Both methods can explore the sequence of events, how the error event breached the safety measures in place, help each HCW understand their role in the breaches, why the safety measures failed and what harms can be attributed to the event (van der Starre et al. 2014). Root cause analysis processes interview HCWs involved in error events by walking through the sequence of events with each HCW involved and discussion with a content expert with a goal of understanding how individual and the collective team critical thinking and situational awareness may have intertwined and contributed to the event. Root cause analysis permit a much deeper and more thorough exploration of error events and in view of their labour intensive nature tend to be reserved for events wherein the harms are deemed more severe in nature. For HCWs, root cause analysis are one of the few continuing education opportunities precisely tailored to them and provided to explore their own critical thinking, and understand the role of uncertainty in decision-making. It models and teaches inductive reasoning biases and identifies the role of "who, how and why" in uncovering thought processes that can impact the scope of differential diagnosis, investigations and treatments of patient care in real time. The integration of root cause analysis into critical care education would meet many of the previously identified strategies identified by Hayes et al. (2017) to improve the critical thinking of critical care trainees and staff alike. If these debriefs are approached in a 'safe space with a safe manner', understanding one's actual contribution to how things went wrong can be an opportunity for personal and professional growth, and participation in advocating for changes, being part of problem solving and developing solutions which can potentially restore HCWs' sense of belonging, of being respected by peers and even more importantly may be a way of regaining self-respect and self-confidence. Even if professional educational needs are identified, the way forward is clear and within the hands of the HCW.

Critical incident and root cause analysis debriefs can result in very practical changes in policies, practices and procedures that can help prevent future events (van der Starre et al. 2014) yet they have not fully realised their potential to do so (Mitchell and Schuster 2016). Widely incorporating what they uncover into future HCWs continuing education is arguably less effectively and systematically performed within any given healthcare organisation (Mitchell and Schuster 2016). This could change moving forward. In critical care, critical thinking in crisis situation requires situational awareness and teamwork to prevent errors. Research has shown that simulation based education can improve both teamwork and situational awareness, reducing error in resuscitation scenarios (Chang et al. 2017; Cheng et al. 2012; Davis et al. 2021; Parush et al. 2017). In the future it would be interesting to use error event simulations as an educational modality and integrate root cause analysis processes in its debriefing time to promote personalised learning of the trainees' and teams in diagnostic biases, the interplay of critical thinking,

communication and situational awareness skills (Hayes et al. 2017). If properly designed we hypothesise that this could be a powerful tool in teaching error prevention and improving patient safety.

Still for many, if not most, involvement in an error event can be psychologically devastating. An error event is a good time to perform a self-check on one's state of physical and mental health and to examine current workload and work-life balance (Mazurek et al. 2021). It is important for all of us to understand the need to take and to give each other opportunities to rest, to address our own needs and recharge. As research has shown error events occur more frequently when HCWs are dealing with their own mental and physical health issues (Mazurek et al. 2021). Feelings of guilt, shame, symptoms of anxiety, depression and post-traumatic stress disorder that ensue after an error event can be very challenging to manage –and will amplify the psychological effects being experienced especially during these current stressful times in healthcare. Even if talking with colleagues can reveal these are normal responses, coping is not easy. It is okay to need and to seek professional help. Healthcare teams and hospitals should have readily available and accessible resources to provide timely interventions to help HCWs recover and prevent long term psychological damage. It would be helpful that preventative support be offered so that HCWs can explore their psychological stress and determine with a professional whether further support is or is not required.

While a significant amount of effort has been placed in improving patient safety and in understanding and decreasing error event, research in understanding the psychological effects of error events on HCWs needs to receive more attention. Now as the pandemic continues to rage, HCWs are seeing increasing workloads as colleagues leave the field, as others are unable to work due to illness or need to self-isolate as cases soar in their own healthcare system and worldwide. Moreover, in many centres, additional stress is arising as HCWs are subjected to increasing threats and intimidation from a frustrated public waiting for testing, vaccination or care. Others are receiving threats for trying to advocate for public health measures on social media platforms. In view of the ever increasing shortages of human resources, many hospitals are considering policies to ask, encourage or mandate that HCWs who are COVID positive and either asymptomatic or mildly symptomatic return to work. Research has shown the correlation between physical and mental health and error events. Even in the face of the human resource challenges of this phase of the pandemic, ways of maintaining the basic needs of HCWs – in Maslow's framework the physiological and safety needs--must be tended to urgently or more error events will become certainties. A greater understanding of the psychological ramifications of such events, and the provision of support and help in recovering from them are crucial for the healthcare system not only to maintain the quality of care it provides but, more importantly at present, to substantially show it values its HCWs in order to retain its highly skilled staff.

> **HCWs are often perceived uni-dimensionally as professionals and the existence of a person inside the professional is either not acknowledged or not accorded the value needed to cope with these challenging events**

Conflict of Interest

None. ■

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Khara M Sauro
Assistant Professor
Departments of Community Health Sciences, Surgery and Oncology
O'Brien Institute for Public Health
Arnie Charbonneau Cancer Institute
University of Calgary
Alberta, Canada

kmsauro@ucalgary.ca
@kharasauro

Henry T Stelfox
Professor
Departments of Critical Care Medicine and Community Health Sciences
Scientific Director
O'Brien Institute for Public Health
University of Calgary
Alberta, Canada

tstelfox@ucalgary.ca
@StelfoxTom

Patient Safety in the ICU: Exploring Trends in Adverse Events in ICUs

Adverse events (AEs) are common among critically ill patients. Evidence about the nature, preventability and predictability of AEs can be used to reinvest in efforts to reduce them and improve patient safety in ICUs.

Case

Mr. A, a previously well 70-year-old male was admitted to the intensive care unit (ICU) with respiratory failure secondary to novel SARS-CoV-2 (COVID-19). He received two weeks of aggressive therapies before his clinical condition improved, had a tracheostomy and was successfully liberated from mechanical ventilation. On day 16, with the ICU at full capacity, he had a clogged nasogastric tube replaced before being transferred to a medical unit. Twelve hours later he was readmitted to the ICU with respiratory failure and copious tube feed-coloured secretions were aspirated from his tracheostomy.

Why did this adverse event (AE) occur? What could have been done to prevent this AE? How should the medical team proceed?

Safety in the ICU

Critically ill patients in ICUs are the most vulnerable patients within the healthcare system. Their critical illness and complex care puts them at risk for AE - unintended negative consequences of healthcare delivery that compromise patient safety (Kohn et al. 2000).

The estimated rate of AEs in critically ill patients ranges widely from 15% to 51% of ICU patients, with considerable variability between studies (Ahmed et al. 2015). The reason for this variation is not well understood but likely is related to patient-level and study-level factors (Sauro et al. 2021). Nevertheless, it is clear that the number of critically ill patients that experience AEs is higher than that of the general hospital population. While an estimated 8% of hospital patients experience an AE (Sauro et al. 2015; Brown et al. 2004; Brennan et al. 1991), most estimates of AEs among critically ill patients are at least twice as high. What drives this large difference and what can be done to reduce AEs and improve safety among ICU patients? The objective of this study is to understand safety in the ICU and explore evolving trends in AEs in ICUs.

Methods

We conducted a sub-analysis of a previous systematic review and meta-analysis of hospital AEs (Sauro et al. 2021) and augmented the systematic review with a narrative review of more recent studies. We included 11 studies that provided estimates of AEs in the ICU from the previous systematic review (from inception of the databases until 2017) and augmented this search with literature examining AEs in ICU from January 2017 until present (October 2021). We searched Medline (OVID) using terms from Sauro et al. (2021) (previous systematic review) and Ahmed et al. (2015) (systematic review of AEs in ICU) using MeSH terms, text words and synonyms related to adverse events and ICU **(Appendix A)**.

1.	exp patient safety/or exp safety/ (85954)
2.	adverse event*.tw. (185474)
3.	exp medical errors (118477)
4.	exp near miss, healthcare/ (258)
5.	mistake*.tw. (24820)
6.	unintended.tw. (15450)
7.	exp iatrogenic disease/ (79579)
8.	exp critical care/ (62590)
9.	exp intensive care units/or intensive care*.tw. (201377)
10.	exp critical illness/or icu.tw. (93281)
11.	8 or 9 or 10 (261941)
12.	1 or 2 or 3 or 4 or 5 or 6 or 7 (487474)
13.	11 and 12 (23100)
14.	limit 13 to (humans and yr="2017 -current") (5187)

Appendix A. Search strategy
Database: Ovid MEDLINE(R) and Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations and Daily <1946 to November 22, 2021>

The new search yielded 4808 non-duplicate references. After screening titles, abstracts, and full-texts three studies were included from the new search. Two additional articles were identified through handsearching reference lists of included

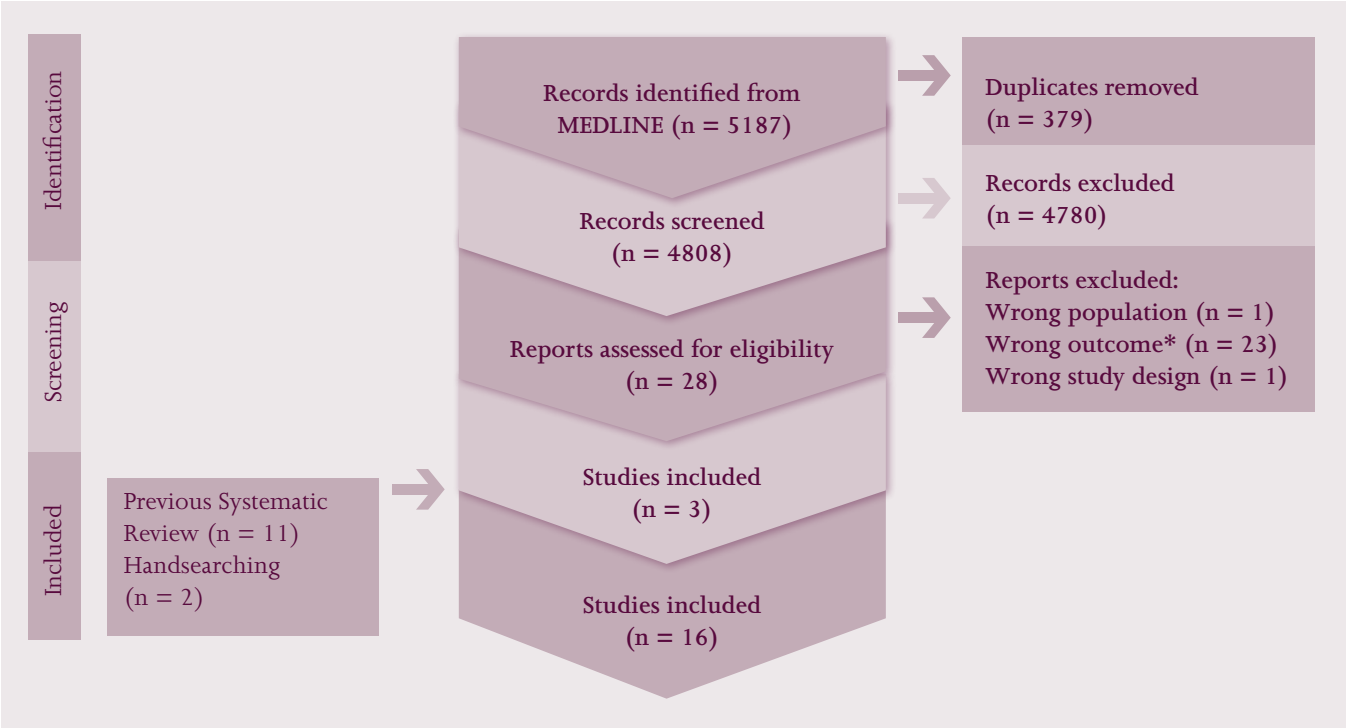

Figure 1. Data flow (PRISMA flow diagram)
*This includes studies that did not provide an overall estimate of adverse events in the ICU.

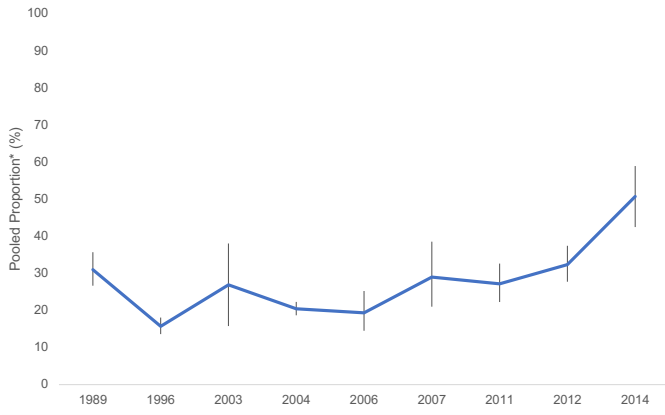

Figure 2. Frequency of adverse events over time
*Pooled proportion across studies was calculated using a random effects model. The 95% confidence intervals for each pooled estimate are represented by bars.

articles. In total 16 studies (11 identified from Sauro et al. (2021) plus five identified from the updated search) were included in this review **(Figure 1)**.

How Common are AEs in the ICU?

Nearly a quarter (24.9%, 95% CI=16.4, 33.3, number of studies [n]=15) of critically ill patients experience at least one AE during their ICU stay, at a rate of 8.5 AEs per 100 patient days (95% CI=6.24, 10.74, n=8). Given that AEs occur more commonly among those who are older, have multimorbidity and more severe illness (Sauro et al. 2021; Sauro et al. 2020a; Zegers et al. 2011; Sauro et al. 2017), it is not surprising that critically ill patients are more likely to experience an AE than the general hospital population, which has been reported to be 8% (Sauro et al. 2021; Baker et al. 2004; Brennan et al. 1991). We also found that the frequency of AEs documented in studies has increased slightly over time **(Figure 2)**; a finding that is corroborated by Danielis et al. (2021) who found an increase in the frequency of AEs from 2013-2017. Overall, the published literature suggests that one in four critically ill patients will experience an AE during their ICU stay and that the incidence may be increasing.

The overall frequency of AEs varied considerably between studies (range = 1.7-50.7) as did the type and frequency of each type of AE. There are several reasons for heterogeneity between study estimates, including differences in eligibility criteria, definition of AE, data collection methods as well as patient, ICU, and hospital factors. Regardless of between study variability, AEs among critically ill patients remains an important clinical problem. Exploring factors that contribute to the high rate of AEs in ICUs is needed to strategically develop evidence-based interventions to improve patient safety.

What is the Nature of AEs in the ICU?

Understanding the type of AEs that occur in the ICU can help inform quality improvement initiatives. Thirteen of the 16 studies reported the type of AEs examined; 10 studies examined drug-related AEs, nine examined nosocomial infections, and eight examined respiratory AEs **(Figure 3)**. There was considerable variation in how AEs were categorised in the absence of an accepted taxonomy of types of AEs. The incidence of each type of AE varied considerably, with the most common types of AE described related to failures in care provision which includes procedure and care management AEs (pooled estimate = 19.27% of AEs), delirium (pooled estimate = 17.97% of AEs), and neurological AEs (17.27% of AEs).

Can We Predict Which ICU Patients Will Experience an AE?

Evidence suggests several patient-level factors increase the risk of AEs in hospitalised patients; age, multimorbidity, surgical interventions, and disease severity (Roque and Melo 2016; Sauro et al. 2020a; Serafim et al. 2017; Valentin et al. 2006; Sauro et al. 2020b). We found similar factors predict AEs among critically ill patients in the ICU **(Table 1)**. A prospective observational study of ICUs from 29 countries, identified disease severity (sequential organ failure assessment [SOFA] score and organ failure) and complexity of care (mechanical ventilation, dialysis and intravenous medication) predicted the occurrence of AEs (Valentin et al. 2006). Similarly, other studies found that older patients with more comorbidities who were either admitted to the ICU from the operating room (surgical patients) or urgently admitted to the ICU were more likely to experience an AE (Sauro et al. 2020a; Serafim et al. 2017). These studies suggest that patient-level factors can identify ICU patients at risk of experiencing AEs. However, Pronovost et al. (2006) have reported that within ICUs patient-level factors contribute to 32% of AEs, while environmental factors contribute to 22% of AEs. ICU-level factors associated with AEs include duration of ICU stay and patient to nurse ratio (Valentin et al. 2006). While these factors have been found to be associated with the occurrence of AEs, can we move beyond association to causation?

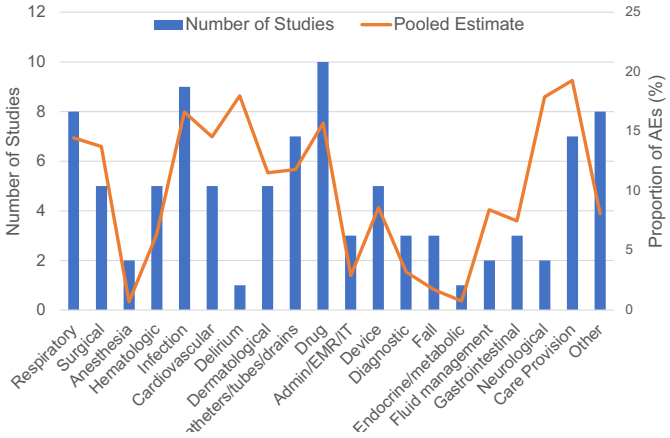

Figure 3. Type of adverse events

Abbreviations: AE = adverse events, EMR = electronic medical record, IT = information technology

Identifying the root cause of AEs is labour intensive and challenging; consequently, there are few published studies. Bracco et al. (2001) examined human factors as the root cause of AEs in ICUs and found that human error was responsible for 31% of AEs, most commonly due to planning (wrong plan to achieve clinical goals), execution (failure to execute clinical plan as intended) and surveillance (failure to identify a change in the clinical status) failures. Of the human error-related AEs, 26% prolonged the ICU length of stay and increased the duration of patients' stay by 15% (Bracco et al. 2001). Other factors that have been found to be associated with the occurrence of AEs in the ICU include training and education of healthcare providers (e.g., knowledge, skills, competency), team factors (e.g., communication between care providers), institutional environment (e.g., physical and human resources, workload), and information technology/electronic medical records (e.g., availability and usability of electronic resources) (Pronovost et al. 2006).

What are the Consequences of AEs in Critically Ill Patients?

Adverse events have a profound impact on patients and healthcare systems. Studies have found that AEs are associated with mortality, increased length of hospital and ICU stay and cost (Bracco et al. 2001; Graf et al. 2005; Kaushal et al. 2007). Rothschild et al. (2005), in a prospective observational study of two 10 bed ICUs (one medical and one cardiovascular), found that 12% of AEs were life-threatening and 2% resulted in death. Similar estimates were reported by Giraud et al. (1993) and Thomas et al. (2012). Garrouste et al. (2008) found that 4% of patients that experienced an AE had a prolonged ICU stay, and nearly 10% resulted in minor morbidity. Roque et al. (2016) found that patients who experienced an AE were twice as likely to die in hospital than those who did not experience an AE. Similar estimates by other authors have highlighted the increased risk of death associated with AEs (Ahmed et al. 2015; Forster et al. 2008; Roque et al. 2016; Sauro et al. 2020a).

In addition to the human cost, AEs are also costly to healthcare systems. Adverse events in the ICU increase the length of a patient's ICU stay with estimates ranging from on average an additional 2.4 days to 31 days (Ahmed et al. 2015; Forster et al. 2008; Roque et al. 2016). In a sub-analysis of the Critical Care Safety Study conducted between 2002 and 2003, AEs were estimated to result in additional costs of $3961 USD per patient. This translated into an additional $853,000 USD per year for a ten bed medical ICU and $630,000 USD for a ten bed cardiac ICU (Kaushal et al. 2007).

These data demonstrate that the impact of AEs in critically ill patients is substantial, justifying a reinvestment in efforts to reduce AEs and improve patient safety in ICUs.

Can We Reduce AEs and Improve the Safety of ICUs?

Since the Institute of Medicine's call to action to improve patient safety in 2000 and the establishment of the World Alliance for Patient Safety by the World Health Organization in 2004, there has been an increase in the number of studies examining AEs (Sauro et al. 2020c). We found a similar trend in the critical care literature with all but two of the 16 studies included in this review published after 2004. More worryingly, the growing number of studies does not appear to translate into fewer AEs. We might be getting better at reporting AEs, but patient safety still needs to improve.

Many AEs are considered preventable; the two studies that reported estimates of preventability found, on average, 43% of AEs were preventable (Forster et al. 2008; Rothschild et al. 2005). This would suggest a large opportunity to reduce AEs. How do we do this? Based on the available data there are two complimentary approaches to reducing AEs: (1) improving patient safety culture and its constituent organisational components and (2) targeting specific high-risk circumstances.

Variable	Measure of association	Study
Patient level factors		
Age	OR=1.04 (95%CI=0.60, 2.33)	Serafim[1]
Disease severity	SAP II: OR=1.22	Bracco[2]
	SAP II: ↑ 10 points	Graf[3]
	SAP III: OR=1.06 (95%CI=1.03, 1.08)	Serafim[1]
	Organ failure: OR=1.42 (95%CI=1.09, 1.85)	Valentin[4]
Course in ICU		
Urgent admission to ICU	OR=4.91 (95%CI=1.95, 12.39)	Serafim[1]
Admitted from operating room	OR=1.8 (95%CI=1.7, 2.0)	Sauro[5]
Admitted from other unit	OR=2.7 (95%CI=2.5, 3.0)	Sauro[5]
Mechanical ventilation	OR=1.76	Bracco[2]
	OR=1.44 (95%CI=1.11, 1.86)	Valentin[4]
Ventricular assisted devices	OR=1.96	Bracco[2]
Intracranial pressure monitoring	OR=1.93	Bracco[2]
IV medication	OR=2.52 (95%CI=1.29, 4.90)	Valentin[4]
Dialysis	OR=1.79 (95%CI=1.17, 2.75)	Valentin[4]
Consequences of adverse events		
Readmission	OR=3.04	Bracco[2]
	OR=4.8 (95%CI=4.7, 5.6)	Sauro[5]
Length of ICU stay	OR=1.26	Bracco[2]
	↑ 8 days	Graf[3]
	↑ 9 days	Roque[6]
	OR=1.53 (95%CI=1.33, 1.75)	Serafim[1]
	↑ 5.4 days	Sauro[5]
	OR=1.16 (95%CI=1.01, 1.33)*	Valentin[4]
Death	OR=2.05 (95%CI=1.17, 3.57)	Roque[6]
	OR=1.5 (95%CI=1.4, 1.6)	Sauro[5]

Table 1. Factors associated with adverse events in ICU

Abbreviations: ICU=intensive care unit, IV=intravenous, SAP=simplified acute physiology score, OR=odds ratio, 95%CI=95% confidence interval

*Risk time in hours

1. Serafirm et al. 2017; 2. Bracco et al. 2001; 3. Graf et al. 2005; 4. Valentin et al. 2006; 5. Sauro et al. 2020a; 6. Roque et al. 2016.

Several studies beyond those included in this review have examined strategies to improve patient safety in ICUs. For example, the Harvard Work Hours and Health Study found that reducing interns' ICU shift hours reduced serious AEs by 22% (Landrigan et al. 2004). Targeted initiatives have also been successful. For example, a multicentre study in the United States implemented a multifaceted strategy to reduce the specific AE of bloodstream infections. The intervention resulted in a decrease of bloodstream infections from 7.7% to 0%, and the results were sustained for 18 months (Pronovost et al. 2010). In both examples the interventions modified structural or organisational factors related to patient safety. There is emerging evidence that suggests system-level factors, such as patient safety culture, play a significant role in the frequency of AEs (Mardon et al. 2010; Kline et al. 2008; Wang et al. 2014). Pronovost et al. (2006) reported that many factors that contributed to AEs in the ICU are structural including institutional environment. The novel COVID-19 pandemic has stressed ICU capacity in many countries and jurisdictions. Evidence suggests that physician burnout and ICU capacity strain are risk factors for preventable AEs that warrant further exploration (Sauro et al. 2020b; Panagioti et al. 2018).

Targeted approaches to reduce AEs could focus on factors associated with the occurrence of AEs or specific types of AEs. Forster et al. (2008) explored which type of AEs in ICUs are preventable and found that procedural AEs were most likely to be preventable (35% were preventable) followed by therapeutic errors (22% were preventable), while surgical complications were least likely to be preventable. There may be value to selectively targeting improvement interventions to these and other AEs that are preventable.

Given the available evidence, it is clear that patient safety (as measured by AEs) continues to be a profound challenge for ICUs and requires urgent attention. We cannot be content with the current state of AEs in ICU. It is time for us to build on the work launched by the Institute of Medicine Report To Err is Human over twenty years ago and redouble our efforts to improve patient safety.

Resolution of Case

Our case highlights the risks of AEs and their potentially serious consequences in critical care. First, the patient had a nasogastric tube inserted; procedures are associated with an increased risk of preventable AEs (Forster et al. 2008). Second, transition of the patient's care from the ICU to a medical ward provided an opportunity for continuity of care to break down (Sauro et al. 2020b). Third, the ICU was experiencing capacity strain at the time of the transition of care, a factor associated with an increased risk of AEs (Sauro et al. 2020b), so that while a chest x-ray had been performed demonstrating the nasogastric tube to be located in the left main stem bronchus, the medical team did not review the images or radiology report. Finally, the patient was cared for by an operating room nurse redeployed to the medical unit due to pandemic staffing shortages who was unfamiliar with the standard operating procedures of the unit and restarted the patient's tube feeds. The error was disclosed to the patient's family. The patient

received 48 hours of invasive mechanical ventilation. There was no evidence of hospital acquired pneumonia, and the patient was moved back to the medical unit after five days of further care that included chest physiotherapy.

In this case, potential prevention strategies could have included the following. First, educating healthcare practitioners and managers about the risk of AEs during periods of capacity strain when individuals may be stressed and distracted might have delayed the semi-elective reinsertion of the nasogastric tube (Bagshaw et al. 2017; Bagshaw et al. 2018). Second, implementing a forced function protocol for radiology consultants to immediately contact the most responsible health care provider for critical diagnostic findings could have resulted in earlier identification and removal of the incorrectly placed nasogastric tube by the clinical team.

> **“there is emerging evidence that suggests system-level factors, such as patient safety culture play a significant role in the frequency of AEs”**

Third, a standardised multimodal transition in care communication (i.e., verbal and written) procedure that ensures important information including the locations and uses of tubes and lines is transmitted to the receiving care team may have prevented the reinstitution of patient's feeds prior to confirmation of the nasogastric tube's location (Stelfox et al. 2017).

Conflict of Interest

The authors have no conflicts of interest to report. ■

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Nicolas Girerd
Professor of Medicine
Centre Hospitalier Universitaire de Nancy
Centre d'Investigation
Clinique Plurithématique
Institut Lorrain du Coeur et des Vaisseaux
Nancy, France

n.girerd@chru-nancy.fr

Diagnostic and Prognostic Value of Estimated Plasma Volume Status

An overview of estimated plasma volume (ePVS), recent evidence supporting the association of ePVS with clinical congestion and whether it can help improve outcomes in patients with heart failure (HF).

Plasma volume (PV) is the level of intravascular fluid minus the red blood cells, white blood cells and platelets. PV in heart failure (HF) patients is associated with increases in fluid compartments. For example, PV could increase by nearly 40% in patients with decompensated HF (Kobayashi et al. 2021). PV can also expand due to accumulated fluid volume leading to impaired pulmonary circulation and hospitalisation. Therefore, a reliable assessment of PV is essential in HF patients. Haemoconcentration is typically determined by a change in haemoglobin or haematocrit concentrations. This can function as an indirect marker of changes in PV.

Estimated plasma volume (ePVS), derived from haemoglobin and haematocrit, has also been shown to have an association with other congestion biomarkers (p.e. E/e' measured in echocardiography). It is a useful diagnostic and prognostic tool in HF management. Elevated ePVS has been repeatedly shown to be associated with clinical outcomes in patients with acute or chronic HF.

Formulas to Estimate ePVS

Two formulas estimate PV.

The first formula was initially proposed by Strauss to estimate changes in PV, solely using haemoglobin and haematocrit.

$$\Delta ePVS = 100 \times \frac{\text{hemoglobin (g/dL)(before)}}{\text{hemoglobin (after)}} \times \frac{100 - \text{hematocrit (\%)(after)}}{100 - \text{hematocrit (before)}} - 100$$

An extension of this formula was first published by Duarte et al. It provides an instantaneous measurement of PV using haematocrit and haemoglobin data from a single time-point.

$$ePVS = (100 - \text{hematocrit (\%)}) \,/\, \text{hemoglobin (g/dL)}$$

The second formula, the Kaplan/Hakim formula, is also used to calculate actual and ideal PV using haematocrit and dry body weight.

$$= (100 - \text{hematocrit (\%)}) \,/\, 100 \times [a + (b \times \text{dry weight (kg)}]$$

These formulas both were reported to predict clinical outcomes in patients with HF. However, in clinical practice, ePVS estimates from Duarte formula represent an easy-to-use tool as it only relies on haemoglobin and haematocrit (and not on dry body weight – something that is difficult to assess in acute settings). An association between classical congestion markers and ePVS has been reported only with the Duarte formula, possibly because the Hakim formula incorporates dry body weight. ePVS derived from the Duarte formula has been reported in a haemodynamic study to be a marker of left-sided haemodynamic congestion. These data suggest that ePVS estimation using the Duarte formula could become a useful congestion marker in the management of HF, but there is a need for large-scale multicentre studies to ascertain the clinical usefulness of ePVS in HF patients (Kobayashi et al. 2021).

There is some controversy as to what ePVS actually measures. Indeed, in some studies, ePVS derived from haemoglobin and haematocrit were sizably different from calculated PV for isotope. The answer is unsettled. However, it is important to note that the methods may not necessarily be measuring the same variable. By essence, ePVS based on haemoglobin and haematocrit are instantaneous estimates, whereas isotopes based method may provide more steady estimates. These differences in timings may be the cause for the variation. Importantly, regardless of these discrepancies, ePVS undeniably has an important prognostic value in the field of HF and HF and can provide a phenotypic characteristic. This can provide clinicians the opportunity to tailor personalised therapy for patients with HF (Kobayashi et al. 2021).

Congestion and ePVS

Congestion is a well-known predictor of outcome in patients with HF, including higher rates of readmission and death. Congestion at the time of admission and residual congestion are both associated with poor clinical outcomes and a major cause for HF hospitalisation (Tamaki et al. 2019). Despite this clearly established association, HF patients are often discharged with clear symptoms of congestion without a pre-discharge clinical

assessment. It is important to detect and monitor congestion before it progresses to decompensation. Similarly, post-discharge assessment of congestion is also not a matter of routine practice. This contributes to increased cost and a higher burden of rehospitalisation. An evaluation of physical symptoms, laboratory reports and net fluid change should be considered part of a pre-discharge assessment. ePVS data is usually available but is rarely looked at despite evidence that it could be associated with improvement in patient outcomes. This is especially true since evaluating congestion in heart failure with reduced ejection fraction (HFrEF) can be difficult.

There is a need for clinicians to identify and use approaches that could improve the management of congestion to prevent readmissions and improve patient outcomes.

ePVS and Acute and Chronic HF

A post-analysis of the EPHESUS (Eplerenone Post-Acute Myocardial Infarction Heart Failure Efficacy and Survival Study) first showed that in patients with HF and left ventricular systolic dysfunction complicating acute myocardial infarction (AMI), a short-term decrease in ePVS using the Strauss formula is associated with better cardiovascular outcomes. In addition, an instantaneous estimation of PV derived from the Strauss formula reported a greater prognostic value (Duarte et al. 2015). Findings from the EPHESUS have been tested and validated in a wide range of other heart failure settings, whether it is acute, chronic, heart failure with preserved ejection fraction (HFpEF) or heart failure with reduced ejection fraction (HFrEF). ePVS and its association with clinical outcomes has also been reported in patients with chronic HF.

Patients with acute heart failure have more interstitial fluid volume. Several reports have found an association between an increase in ePVS and a higher risk of clinical outcomes. Increased ePVS at discharge has been found to be associated with poor prognosis. Hence, the clinical and prognostic value of ePVS at discharge and post-discharge can be valuable. While this may be challenging, it can help optimise patient management and prevent hospital readmissions (Kobayashi et al. 2021).

> **“a higher level of ePVS is independently associated with a higher risk of in-hospital death and a lower possibility of survival during hospitalisation”**

In a recent study by Chen et al. (2021), higher ePVS calculated from the Duarte formula was found to be associated with poor prognosis in patients with AMI. The main findings from the MIMIC-II study show that a higher level of ePVS is independently associated with a higher risk of in-hospital death of patients and that patients with higher-level ePVS have a lower possibility of survival during hospitalisation compared with patients with a lower-level ePVS.

Overall, it is important to recognise the clinical and prognostic value of ePVS and a careful pre – and post-discharge congestion assessment. Estimation of PV with the Strauss formula or Duarte formula can be a useful strategy and can have important clinical implications for patient management and improved patient outcomes. It should be assessed and closely monitored, and this can be done through serial measurements of ePVS using either blood count or body weight. ePVS has been repeatedly shown to be associated with outcome, even in patients hospitalised for AMI. However, ePVS estimation remains probably an underused strategy even though it can be useful to guide treatment strategies in patients with HF. Yet, we still need large-scale outcome clinical trial to clarify the impact of ePVS-guided management in patients with HF..

Key Points

- Estimated plasma volume (ePVS) is a useful diagnostic and prognostic tool in heart failure (HF) management.
- Elevated ePVS can be an important predictor of all-cause mortality in patients with HF.
- The Strauss formula and Duarte formula are routinely used to estimate plasma volume.
- ePVS enables repeated (and unexpensive) evaluations of congestion.
- Large-scale outcome clinical trials are needed to determine whether ePVS-guided management should become the standard of care in patients with HF.

For more details visit https://iii.hm/1eiy

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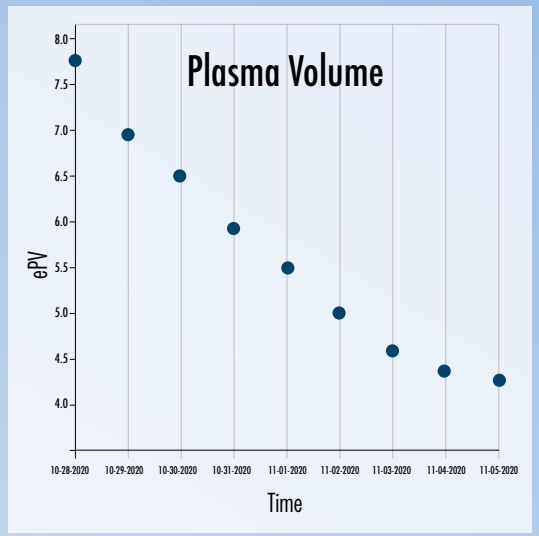

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Plasma volume status is vital in testing critically ill patients but is extremely difficult and costly to obtain, particularly as a POC test. Plasma volume assessment affects almost every aspect of a patient's care, including giving IV fluids, diuresing, starting vasopressors, initiating renal replacement therapy, deciding on transfusion requirements and intubation and extubation.[1,2]

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Information Transfer as a Strategy to Improve Safety in ICU

The transmission of information (TOI) in extremely variable environments, such as the ICU, is crucial. The content and how it is transmitted can be decisive in the safe care of the critical patient.

Irene Salinas Gabiña
Intensivist
Intensive Care Unit
Hospital Universitario del Henares
Coslada-Madrid, Spain
Professor of Physiology
Facultad de Medicina
Universidad Francisco de Vitoria
Pozuelo de Alarcón
Madrid, Spain

irenesalinas@hotmail.com

Sonia Pajares Martínez
Resident
Intensive Care Unit
Hospital Universitario del Henares
Coslada-Madrid, Spain

soni_pm93@hotmail.com

Federico Gordo Vidal
Head of Department
Intensive Care Unit
Hospital Universitario del Henares
Coslada-Madrid, Spain
Grupo de Investigación en Patología Crítica
Facultad de Medicina
Universidad Francisco de Vitoria
Pozuelo de Alarcón
Madrid, Spain

fgordo5@gmail.com

Introduction

In an Intensive Care Unit (ICU), we attend people with a wide range of pathologies. All the information obtained from monitoring our critical patients, diagnostic and therapeutic techniques, responses to treatments, action plans, etc. is the greatest asset that a professional has available to carry out and optimise his work and that of his colleagues and patient's prognosis in a high-risk environment.

The transmission of information (TOI) among the ICU team members is a 'soft skill' that is applied by different types of professionals and is fundamental for the continuous 24/7 care of critical patients. It is called handoff or handover communication, but we prefer to employ the term TOI because an integrative communication is not only important for the efficiency of the attending healthcare team, but also for health communication with the critical patient and their family. It has also been shown to increase the objective quality (prognosis at discharge) and perceived quality by the patient. Adequate TOI, like any other tool or technique, requires training to be performed in a professional manner and is essential for the safe care of the critical patient.

The need to transmit information in an effective way appeared with the beginning of the first 'ICUs' in the 1950s. TOI is necessary for patient changes of location and for shift handoffs. The publication of articles about TOI in the critically ill patient began in the 1980s. The desire to innovate and improve is not a routine in the day-to-day work of an ICU, despite the intention of the ICU teams to develop patient safety protocols for the TOI process shown in studies (Häggström and Bäckström 2014; Wessman et al. 2017; Sirgo et al. 2018). Perhaps this is because there is no gold standard TOI (Da Silva et al. 2018). The multidisciplinary teams, the very different pathologies that are treated, their complexity and the local routine of each ICU all make it difficult to transition from intention to practice.

Each TOI reflects each professional's own experience. Reflecting on TOI, we can identify opportunities for learning and improvement that will help us during challenges such as the COVID-19 pandemic (Ballesteros et al. 2020).

Objective

The objective of this article is to promote optimal transmission of information (TOI) in the care of critical patients as good clinical practice (GCP). It is part of a multidisciplinary, cross-cutting safety strategy that benefits patient outcomes, staff performance, ICU team efficiency and the organisation sustainability.

This article is not intended to be an exhaustive review of TOI tools. We consider it important to enrich our practice through various publications. This involves us in the improvement of healthcare through learning that is applicable in the day-to-day life of the entire ICU team, with each other and with patients and their families.

Adequate TOI Enhances ICU Safety

The complexity of ICU workflow, with its cognitive, linguistic, technical, and physical demands requires a TOI protocol included in the overall strategy to increase patient safety. Secure handoff communication promotes adequate continuity of care.

ICUSRS, SEE, ENEAS, IDEA, SYREC* study (Merino et al. 2007) and studies already well known (Pronovost et al. 2006) show that inadequate communication can be behind any type of incident due to [according to International Classification for Patient Safety (ICPS)]: ambiguous verbal orders or comprehension problems

related to lack of education or training. National Patient Safety Agency (NPSA) suggests that with proper TOI training, these incidents would be avoidable (Rhudy 2019). By avoiding them, we would maximise the safety of patient reported experience (PREMS) and patient reported outcome measure (PROMS) (Sirgo et al. 2021). The residents themselves have published that inadequate shift handoffs (Rattray et al. 2018) can lead to delays and duplications in diagnostic and therapeutic tests, greater patient discomfort, inappropriate care, poorer team performance, medication errors, failures in patient follow-up and longer stays.

The Joint Commission (The Joint Commission 2021) recommends the development of 'structured procedures' for communication by adopting eCQMs (electronic clinical quality measures) and HIT (Health Information Technology) driven quality improvement practices. The goal of Patient Safety Systems (PS) is to redesign a patient-centred system that improves quality of care and patient safety. The Patient Health Strategy of the National Health System 2015-20 (Estrategia de Salud del Paciente del Sistema Nacional de Salud 2015) promoted communication between professionals to ensure that the information transmitted is accurate, appropriate, directed to the right person and it recommended the implementation of structured communication techniques (Sirgo et al. 2018).

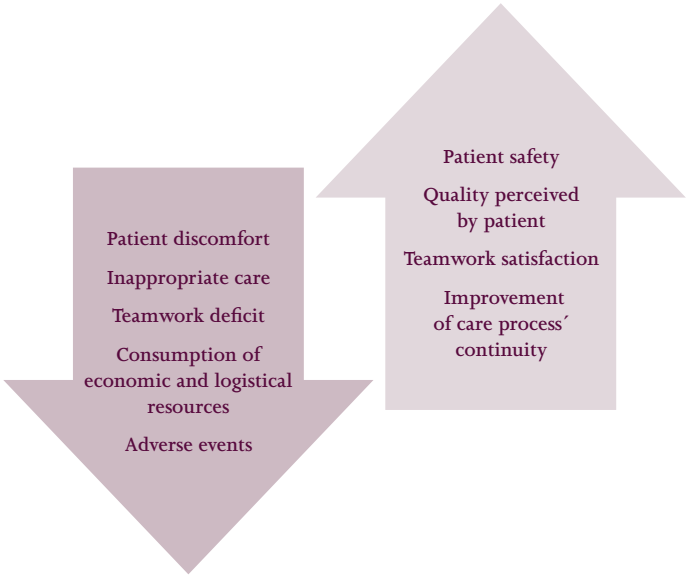

Figure 1. Expected results after implementation of adequate TOI protocol

Characteristics With Greater Safety Risk in the ICU and Benefit from Adequate TOI

- **Transfers:** With every change of location or level of care (emergency room, ward, operating room, ICU), the responsibility and person in charge is also transferred. This TOI is based on the secure, encourage, collaborate (SEC) model (Häggström and Bäckström 2014). It involves ensuring that everything is understood, personalising information by resolving doubts and maintaining the care process through pre- and post-ICU follow-up (Abella et al. 2016), especially in patients with a long stay. If the patient is discharged from the ICU, it requires greater organisation before, during and after the transfer. It is because the patient leaves a highly technical unit (Häggström and Bäckström 2014) or the patient is not able to communicate adequately or feels dependent on ICU technology or staff. Here TOI is crucial to optimise the chain of care and avoid readmissions to the ICU. Temporary TOI (changes of medical shift, nursing shift, transfer of a patient for a diagnostic or therapeutic technique) is very frequent and, therefore, it is important to reduce risks with an adequate TOI.

- **Patient-dependent:** age, date and time of admission and discharge, readmission, pathology (Calleja et al. 2020), specialties involved (Puzio et al. 2020), time-dependent diseases, etc.

- **Dependent on the type of hospital:** number of beds (hospital and ICU), type of ICU, number of admissions/years, nurse/patient, and doctor/patient ratio, nine equivalents of nursing manpower user score (NEMS), inadequate supervision, unplanned processes, lack of risk assessment and lack of solutions for known problems.

- **Dependent on the roles of the people performing the TOI:** Must be individualised. Depending on the transmitter and receiver of the information, both the content, context, and the way of transmitting it may not be the same. It can be divided into:
  - **Intradisciplinary TOI:** consultants to consultants, residents to residents, nurses to nurses.
  - **Interdisciplinary TOI:** consultants to nurses, residents to nurses, consultants to residents, ICU staff to specialists outside the ICU, all of them to the patients and all of them to the families (Bressan et al. 2019; Loefgren and Anderzén-Carlsson 2020).

What Constitutes Adequate TOI?

Initially the TOI studies were retrospective analyses, then prospective observational and pre- and post-intervention studies, protocols as SNAPPI, infinite checklist, or a mnemonic rule for example SBAR (Abassazde 2021), HAND-IT, and SOAP.* Experiential descriptive studies (Häggström and Bäckström 2014) have been carried out (based on qualitative content surveys) to the staff working in an ICU, to patients admitted to the ICU and their families. The studies have focused on looking for factors contributing to better TOI, methods to solve the problems encountered and their effects on critically ill patient safety risks (Da Silva 2018) and healthcare services (Raeisi et al. 2019). They found incomplete or incorrect information in the handoff caused by lack of standardisation and TOI preparation, which generated incorrect procedures, or their delay or non-performance. The use of tools reduced both omitted information and errors, improving team satisfaction.

Previous publications emphasised the use of checklist to avoid omissions. Omissions decreased by 21% in the handoffs and transitions in critical care (HATRICC) study (Lane-Fall et al. 2020). The more protocol steps were followed, the less information omissions occurred. This did not lead to changes in days of stay or mortality and did increase the duration of TOI. Have we reached the ceiling for improvement in patient safety and outcomes? Have we overlooked any TOI deficits that have not been resolved?

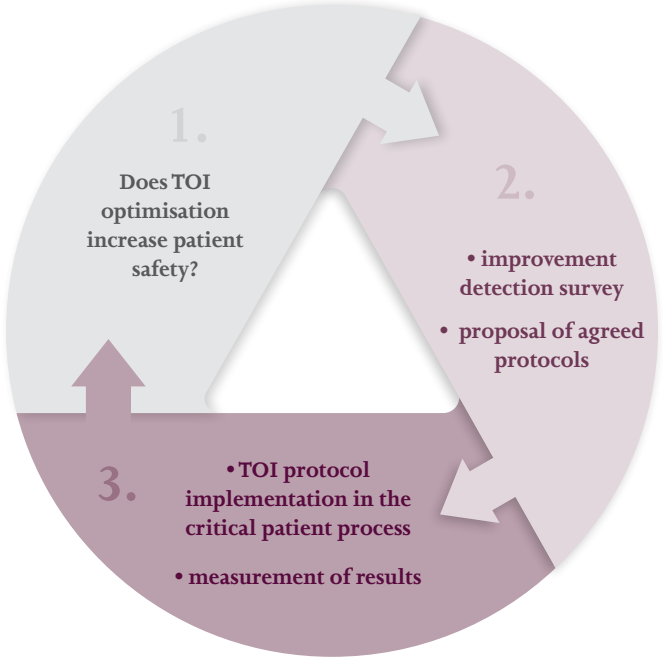

Figure 2. TOI optimisation process

(Fleming et al. 2016). Perhaps we have yet to define what good TOI is (Nasarwanji et al. 2016), both its content and its context (Lane-Fall et al. 2020).

The TOI in an ICU is a very complex social interaction. They have the purpose of providing 24/7 patient care. TOI allows effective communication between professionals who work together frequently or not. That handover of information is 'care' offered to the critically ill patient. It is not only about data. It also implies a handover of inter and intradisciplinary responsibility within the care team. An adequate TOI minimises risks in the continuum of care by reducing failures and optimising clinical care and prognosis (Alexander 2021).

The objective of TOI is operational, oriented to anticipating problems and strategic planning for the patient, and intrinsically formative. In the real-world of our ICUs, TOI must be customised. It always has three components: place, time, and people. All of them are facilitators. The period in which TOI takes place defines the people, spaces, and content of TOI. Although an ICU involves continuous care, most of it occurs in the morning hours. During this period, techniques, programmed interventions, consultation of other specialties, resident rotations, and most admissions (early detection of patients at risk) are performed (Abella et al. 2013). This schedule differs on weekends in that the end-of-morning duty clinical round is not usually performed. On those days, team huddles (if any) are used.

How to Determine TOI in the ICU is Adequate?

Initially, different ICU´s chose to use various checklists. More than 20 mnemonic rules (Nassarwnji et al. 2016) have been described. These may be valid in certain contexts (Weller et al. 2014), but they can constrain TOI. In fact, rigid protocols have not been successful. TOI is now approached as a process map in which the role and responsibility of each team member is defined for each time frame and every given patient within a framework of individualised and precision medicine. The expected common goal is defined, each step is evaluated, and appropriate changes can be initiated according to the deficits detected.

TOI modes vary according to the context or time of day. For example: briefings/debriefings or team huddles of the healthcare team:

- **Briefings:** short meetings in which roles are assigned, expectations are set, and diagnostic tests to be performed or patients to be discharged or admitted are anticipated. It is essential to know if each recipient understands and assumes what has been agreed. Example: the 8:00 a.m. clinical round.
- **Debriefings:** exchange of information after the team's performance, analysing what has been done. Example: the meeting that closes the morning shift and starts the on-call period.
- **Team huddles:** maximum 15 minutes, in which each member points out the priority objectives of their patients and readjustments are made. Example: clinical rounds at shift changes followed by the debriefing part, medical to nursing clinical round at shift changes or vice versa. Also used during TOI on weekend on-calls.

TOI is also about informing patient and family, checking the understanding of what is reported (the terminology used should not be the same), resolving doubts and providing a prognostic assessment.

TOI involves building a common image of the patient with the patient, the patient's family, and the attending team. This reduces differences in criteria, prevents errors in care, provides individual and collective learning and improves perceived quality.

If more than two people interact in the TOI process, it is recommended that a professional with a transversal vision and experience in the ICU analyses issuers and receivers and manages time, the order of exposure and interruptions. This position can be performed between 8:00 a.m. and the end of the morning by a service or section chief and during shift changes from medicine to nursing by the consultant on duty.

Structure and Content for Adequate TOI

Information. It depends on what each ICU considers essential for quality care. It depends on patient factors (complexity, time of evolution) and environment. Recent literature suggests a change in the conceptualisation of TOI from being a transfer of very precise data to being not only a technical but also a highly contextualised social event (Ruiz 2020; Militello et al. 2018). Required to identify patient, pathology, and stage, framed in the global analysis of each patient.

Executive function. Practical approach in a high-pressure healthcare environment. Focused on finding consensual solutions for a quality continuum of care by uniting a shared purpose and motivation. Reach a shared multidisciplinary image of each patient.

Oral format. Concise and specific. Details can be consulted in a written clinical note. Providing visual material is appreciated:

photos, videos, complementary tests or clarifying drawings with different communication technology.

TOI order. According to number of boxes, complexity, persons present.

TOI methods: Narrative, mnemonic rules, Q&A. Open questions, and feedback are fundamental. The process should be individualised. The contribution in relation to applied cognitive task analysis (ACTA) (Militello and Hutton 1998) focused on complex tasks is noteworthy (Methangkool et al. 2019; Coiera and Tombs 1998; Flemming and Hübner 2013).

Face to face. Between transmitter and receiver, ensuring that the objectives and the person responsible for them are clear.

Algorithms in the form of deep learning. Not a specific one or a checklist. It is about having an internal learning of tools, almost automatic, that serves as a script of symptoms, explorations, technological parameters, and deductions. This makes it easier to follow the evolution of the data throughout patient care.

Innovative transmission. To support the retention of data during the on-call or shift.

Time to be spent. It depends on patient complexity, length of stay in ICU, new personnel, new technology or protocols. Time should be individualised, including relationships with the patient and family.

Wellness environment. Shared decisions, conversations and comments involving multidirectional teaching and learning, clinical rounds without fear of what people will say. Interactive and multidisciplinary.

Avoid unnecessary interruptions. Write down concerns and tasks on a sheet to transfer them to the sender after TOI.

Feasible by anyone. With or without experience, requiring only minimal training and useful for continuous learning with a positive impact as a team.

Performing TOI at the bedside. Makes it possible to access information from the environment: monitoring, special technology, being able to capture new data.

The goal is to foster on-call autonomy with the ability to make responsible and timely decisions by finding areas of improvement in each patient and performance with practices that guarantee care continuity.

How does TOI not improve? By listing long data, by reporting what is not a problem to be solved or by informing about something not worth paying attention to. With these things, we lose focus on what is important, we lose attention, and we waste time.

We have no doubt that TOI in the ICU is important. These are our TOI process improvement tips.

Decalogue premises to improve information transmission in critical patient

1. TEAM. Everyone must be aware of TOI process/protocol: role, content and context. Multidisciplinary scheme: Joint info handover will increase information exchange.
2. ENVIROMENT. Relaxed, interactive, no hierarchical pressures, respectful, facilitating the process. Face to face, non-verbal as well as verbal language.
3. TOI CONTENT. Basic elements:
   - name and age
   - pathology and its singularity
   - medical record (issues from start or relevant for further evolution)
   - active health issues evolution
   - diagnostic/therapeutic techniques that may provide information
   - build an agreed plan for staff on-call
   - individualised forecast for future problems
4. Mnemonic TOOLS as a base to support information in the team and to avoid relevant oblivions.
5. TRUE, objective and individualised transmission of patient info with documentary support.
6. TO SHARE information transmitted to patient and family, knowing who is who in the process.
7. FAMILY: Using accessible language, asking for feedback of what has been informed, putting data in context and tracked evolution.
8. TRANSMITTER: Skilled staff with continuous IT training, able to clarify doubts and verify data to ensure info transmission in the right moment, in a pedagogical way for new starters, shift changes, residents, ...
9. A right PLACE, quiet, free of interruptions and non-noisy LOCATION.
10. A fixed TIMETABLE, one more ICU activity, maybe the only one that can be programmed in a fixed scheme.

Figure 3. Decalogue premises improve TOI

The important thing in TOI is the message to be transmitted. This message includes three components: structure, content and who the transmitter and receiver are. Transmission tools are cognitive aids that can increase the quality of our TOI. There is no one tool that is the best for all environments or times. We propose a framework in which the transmitter chooses, if desired, a tool that helps the TOI with its structure.

TIMETABLE	SPACE	TARGET	EMITTER RECEIVER	MEETING	ORDER OF EXPOSITION OF PATIENTS
8:00 h From Monday to Friday, on-hours	Working room for shift handoffs	Handover after end of shift	Outgoing on-call intensivist - Incoming consultant, residents, and nursing supervisor	Briefing	According to box number unless medical urgency prioritises a different order
13:00 h From Monday to Friday, on-hours	Working room for shift handoffs	Clinical rounds: info shared once on-call period starts.	Consultant, residents, and patient care nursing	Debriefing + team huddles + check-list?	According to box number unless medical urgency or nursery availability prioritises a different order
13:00 h Weekend	Usual working room	Goals reshaping	Consultants +/- residents	team huddles	Patients with active problems
<1/4 15 minutes before shift changes at 8:00 a.m., 15:00 p.m. and 22:00 p.m.	Nursing control desk or patient bedside	Intradisciplinary handover from outgoing to incoming staff shift	Two consecutive shifts nurses	Debriefing + checklist	Based on patient prioritisation
>1/4 h 15 minutes after shift changes 15:00 p.m. and 22:00 p.m	Nursing control desk or patient bedside	Interdisciplinary clinical rounds to goal setting for the shift	Consultants +/- residents and nurses of that shift	Briefing	Based on patient prioritisation
At patient admission, every morning and on demand	Patient´s bedside	PATIENT	Consultants, residents, nurses, and patient	Debriefing + resolution of doubts	Based on patient prioritisation
At 12:00 a.m. on a mandatory basis, at 7:00 p.m. if there are any significant developments and, of course, on admission and discharge.	Family information room, located at the entrance of the ICU and used exclusively for this purpose and at the bedside in the patient's box.	FAMILY	Consultants +/- residents, family members present or by phone according to Covid standards	Debriefing + resolution of doubts	Based on patient prioritisation

Figure 4. What and where information is shared

Finally, it is essential to monitor the process. We can rely on satisfaction surveys on quality perceived by the healthcare team attending the patient and the patient himself. There may be barriers in this TOI optimisation process, not only to change but also to thinking about change, due to physical or mental fatigue, stress, lack of time, lack of teamwork culture, communication training or thinking that it is not important. Feedback for improvement processes with constructive conversations should culminate in solutions that can be applied in situ.

Benefits of Proactive ICU TOI Process Design for Critical Patient Safety

For the patient

- Maintain their safety, evolve in the best physical and emotional conditions.
- Avoid physical or temporary gaps in the care received by patients due to changes in the person in charge.
- Patient as centre of care: TOI essential to the success of treatment and the quality perceived by patients and families.
- Transparency in the TOI process: knowing who is responsible for the patient.
- Receive consistent answers that do not differ depending on who performs the TOI.
- Adapt to patient fragility and family situation.
- Identify causes of poor TOI to avoid mortality, morbidity, adverse events, re-admissions.

For the care team

- Work as a team 24 h/365 days a year.
- Coordinate, collaborate between different roles.
- Adapt workloads.
- Convey functional information with a solution-focused structure.
- Support shared reflective practice with critical thinking.
- Empower the recipient of that information to improve the established plan with the patient.
- Quality independent of the issuing professional's status or skills.
- Increase the satisfaction of the professionals.
- Promote learning, motivating staff in a culture of safety by modulating intimidating behaviours and providing resources and improvement initiatives.

In terms of system sustainability

- Protocols for standardisation of assistance at maximum levels and in soft skills.
- Avoidance of designated medical event (DME) and adverse event (AE), moving from ICU as a risk area for adverse events to the opposite.
- Savings in material (consumable or not), logistic (availability of ICU beds) and human resources derived from this.
- Identification of problems and solutions common to different roles or work teams.

Proactivity in the quality-of-care increases knowledge and responsibility, reducing the negative impact of chance. Adequate TOI should be part of the work of healthcare personnel. This can reduce harm and increase safety in patient care.

Proper TOI in the ICU may be learned. TOI itself is a learning moment. It is not a matter of preparing the clinical round according to what happened during the on-call period, but rather that what happened is meaningful, and giving meaning to the decision-making process during the on-call period.

There are six skills of effective TOI: identifying what information is appropriate, providing anticipatory planning, applying acquired clinical knowledge, being concise, being orderly, and considering the preferences of the TOI recipients (Rattray 2018). TOI is like an iceberg because the little you see (hear) is a small portion of all the groundwork involved. We propose to get out of the comfort of routine and take actions that improve present and future clinical care, individually and collectively. The team of each ICU is the one who must identify the needs using every day to detect and learn. However, institutional support is decisive for its effectiveness.

The Accreditation Council for graduate medical education (ACGME) requires hospitals accredited for resident training to develop communication skills during TOI. How should our residents learn? The clash between formal teaching and how things are done at each site contributes to the lack of effectiveness of TOI. Is it better to have 'formal' training (courses with standardised content) or informal training by immersion in the 'local culture'? The immersive model, by osmosis of peers, can vary infinitely. We will have to assume "minimums" in terms of form and TOI content. But formal learning fails to make residents feel prepared for adequate TOI. Residents value more experiential learning, based on practice, performing TOI, living the problems of the ward to make with them an adequate TOI and grow in autonomy (Militello et al. 2018). Evidently, formal education does not convey the critical role that real time has in TOI. In addition, interventions by consultants or senior residents can positively influence this process as events unfold. Militello et al. (2018), in his study on how residents prepare for on-call, highlights that TOI is very intuitive, but a broader conceptual framework is required to improve the process and implement measures of TOI quality (Burgess et al. 2020).

At this point, Díaz-Navarro's contribution with the "TALK© values" (Díaz-Navarro et al. 2021) stands out: constructive, positive, solution-focused reflections, professional and step-by-step communication. Teams should begin by identifying the good practices that should be maintained and disseminated, and the problems to be addressed by the team itself (example: changes in the assignment of tasks).

Our effort is to make sure that this teaching has a real impact on healthcare. In 2020, the COVID-19 pandemic (Ballesteros et al. 2020) has shown the need to adapt training in comprehensive and cross-cutting communication to the changing requirements of clinical practice. It is necessary to evaluate the impact that TOI has on healthcare work, on relationships with patients, families,

and society. Person-Centred Clinical Communication (PCCC) (Ruiz 2020) is a tool for physicians to achieve their clinical objectives.

Conclusion

Knowing is half the battle. Doing is the other half. With this summary we intend to improve knowledge, skills, and personal competence by recommending methods that will improve the quality of sharing information, handoff tools, as an essential component in the safe care of our patients in the environment of care of an ICU.

Conflict of interest

Authors have no competing interests. ■

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Jorge López-Fermín
Hospital General San Juan del Río
Querétaro, México

salemcito1@hotmail.com
@MD_FERMIN

Diego Escarramán-Martínez
Centro Médico Nacional "La Raza" IMSS
Ciudad de México, México

diego-piloto@hotmail.com
@diegoescarraman

Raymundo Flores Ramírez
Hospital ISSSTEP
Puebla, México

rayf_7@hotmail.com
@RayoFR7

Raúl Soriano-Orozco
Unidad Médica de Alta Especialidad T1 León
Guanajuato, México

lacrimozart@hotmail.com
@intensivemd

Doing More Can Be Worse: Ten Common Errors in the ICU

Some of the most common interventions in the ICU can be associated with poor results. We present ten situations in which doing less is better for the critically ill patient.

Introduction

For decades, the focus of patient management in the Intensive Care Unit (ICU) has been to perform a large number of interventions in critically ill patients, many of which are based on clinical judgment and the pathophysiology of diseases. However, evidence for such practices many times does not support them. We present 10 common clinical situations in which doing more could be associated with a higher risk of worse outcomes.

1. Fluid Overload

Intravenous (IV) fluid therapy is the mainstay treatment for patients with hypovolaemia, commonly due to blood loss or dehydration. However, it has been shown that <50% patients in the ICU can be categorised as responders to IV fluids. Unwarranted IV fluid prescription can be unfavourable since fluid overload leads to endothelial damage with direct involvement of the glycocalyx, increased vascular permeability to the extracellular space, increased pressure in encapsulated organs, and multisystem oedema.

Adverse events most frequently related to volume overload are acute kidney injury (AKI), prolonged hospital stay, pulmonary oedema, effusions, increased days on invasive mechanical ventilation (IMV) and higher mortality (Malbrain 2018; Pérez-Nieto 2021).

It is common for patients with AKI in the ICU to be treated aggressively with IV fluids. Nonetheless, congestive renal failure related to irrational fluid therapy is associated with worse outcomes as shown in multicentre studies such as REVERSE-AKI 2021 and FINNAKITRIAL, in which restrictive fluid therapy strategies were associated with less adverse effects including overall cumulative fluid balance and mortality.

In septic shock, the Surviving Sepsis Campaign recommendations published in 2021 recommend aggressive IV fluid therapy with crystalloids at a dose of 30 ml/kg. However, evidence supporting this recommendation is weak and increasingly questioned since multiple cohort studies have shown that only 3% of patients with septic shock will be fluid responsive within eight hours of admission and will no longer benefit from fluid therapy (Pittard 2017; Cordemans 2012; Flori 2011). Furthermore, a positive fluid balance of more than 2 L is associated with increased mortality.

The role of hidden fluid must also be taken into consideration, as it accounts for about a third of the cumulative water balance involving fluid from drug vials, intravenous lines, enteral nutrition, and blood products, making the intention of a benefit a cause of harm (Branan 2020). IV fluid therapy in the critically ill patient must be justified millilitre by millilitre and overload must be avoided at all costs.

2. Oversedation

Sedatives are commonly used in the ICU. Sedation is indicated in patients with moderate to severe acute respiratory distress syndrome (ARDS), patients with intracranial hypertension (ICH) and other scenarios. The drugs of choice are propofol and dexmedetomidine. However, a large proportion of patients do not require sedation and could be managed with adequate analgesia only and, in case

Éder I Zamarrón-López
Hospital IMSS No. 6
Ciudad Madero
Tamaulipas, México

ederzamarron@gmail.com
@ederzamarron

Orlando R Pérez-Nieto
Hospital General San Juan del Río
Querétaro, México

orlando_rpn@hotmail.com
@orlandorpn

All authors are members of Sociedad Mexicana de Medicina Crítica y Emergencias

of agitation, anxiolytics or antipsychotics (Park 2019).

Unnecessary sedation is harmful for critically ill patients. A recently published re-analysis of the NON-SEDA study showed that patients who remained sedated for agitation or respiratory failure had worse outcomes, including more IMV and ICU days, as well as a higher incidence of delirium, despite no impact on mortality (Nedergaard 2022). Prolonged sedation limits early rehabilitation with active mobilisation. Benzodiazepines as sedative agents are associated with worse outcomes and are not recommended as first choices (Park 2019). In patients with ARDS, daily interruption of sedation has been shown to be associated with decreased days of IMV, hospital stay, and mortality (Kress 2000). Combining this strategy with a daily spontaneous ventilation test can lead to better results (Girard 2008).

3. Irrational Use of Antibiotics

Sepsis is one of the most frequent diagnoses in the ICU. Early treatment with antibiotics (<1 h) has been associated with better outcomes (Kollef 2021). Nevertheless, there are patients without confirmed or suspected infections who do not require antibiotics. Unjustified antibiotic prescription contributes to antimicrobial

> **“a large proportion of patients do not require sedation and could be managed with adequate analgesia only”**

resistance, which is already a problem in most hospitals with high incidence of infections by multidrug resistant pathogens. Adverse effects that can occur when using unnecessary antibiotics include mild to severe gastrointestinal disorders (i.e., *Clostridioides difficile* infection), arrhythmias (azithromycin), seizures (carbapenems), etc. With suspected infection, cultures should always be requested, and therapy adjusted, as antimicrobial stewardship is safe and associated with fewer complications (Ilges 2021) and lower mortality.

During the COVID-19 pandemic, inappropriate antibiotic treatment has been at its peak. Azithromycin and other macrolides, nitazoxanide, ivermectin, cephalosporins, and other drugs have been indicated without evidence of benefit (RECOVERY trial 2020-2021). The overall impact of this therapeutic misconduct remains to be characterised.

4. Prophylaxis of Gastrointestinal Ulcers

Proton pump inhibitors (PPI) and histamine-2-receptor antagonists (H2A) are commonly used in critically ill patients to prevent gastrointestinal ulcers by decreasing acid production. Nevertheless, this acid is a barrier to external pathogens, reason why suppressing their secretion could promote intestinal and lung infections. PPIs may also cause alterations in leukocyte function phagocytosis, and acidification of the lytic phagolysosome (Buendgens 2014; McDonald 2015).

There are many questions regarding whether there is benefit from their routine use or not, especially in the absence of clear indication such as upper gastrointestinal bleeding. Studies differ in proving the benefit in groups using these interventions. On the other hand, adverse events can be increased. For instance, mechanical ventilator-associated pneumonia (VAP), *Clostridioides difficile* infection (Trifan 2017), increased hospital stay, and no reductions in mortality (Alhazzani 2017; Marker 2018). Enteral nutrition itself may be associated with decreased risk of gastrointestinal ulcers (Huang 2018).

5. Inappropriate Blood Transfusions

Transfusion of blood products in critically ill patients has precise indications, such as haemorrhagic shock, severe anaemia, or coagulopathy. Unnecessary administration of blood products is associated with complications including increased length of hospital stay, transfusion related acute lung injury (TRALI), transfusion associated circulatory overload (TACO), increased costs, and higher mortality (Fung 2019). The lack of knowledge of standardised blood product transfusion protocols results in the irrational use in the ICU (Spahn 2019). Currently, restrictive transfusion therapy is associated with better outcomes, and it may be better not to transfuse when haemoglobin levels are between 7-8 g/dl without active or massive bleeding (Alexander 2021). Guiding the amount and type of transfusions by viscoelastic tests has also not been shown to be better when compared to conventional coagulation tests (ITACTIC trial 2020).

6. Abuse and Misuse of Laboratory Tests

Blood tests for critically ill patients in the ICU have become routine rather than being based on diagnostic workups. Blood sampling should only be justified on the principle of objective intervention (Angus 2014). The usual indication of ordering daily blood samples from patients represents the unnecessary and unjustifiable retirement of 40-70 ml of blood every 24h (Ñamendys 2019). Consequently, a decrease in haemoglobin of about 1-1.2 g per day has been demonstrated (Fung 2019), leading to iatrogenic anaemia that may even require transfusion of blood products (Smoller 1989). Prospective trials should aim

to reduce the volume of sample collected (paediatric phlebotomy tubes, reduced volumes of syringes, etc.).

7. Invasive Monitoring

Pulmonary artery catheterisation - Swan-Ganz catheterisation - was popularised in the 1970s to perform invasive monitoring in the ICU by providing the estimated value of cardiac output through thermodilution and measurement of right heart chamber pressures as well as pulmonary circulation. By the end of the last century, a high rate of serious complications associated with this procedure were reported. Several clinical trials failed to demonstrate the benefit of this technique for critically ill patients, reason why it began to be discontinued (Marik 2013). As a risky procedure that requires trained medical and nursing staff to perform the measurements properly, with greater time and resources demands, this technique has now been abandoned in most ICUs. The debate of its usefulness in patients undergoing cardiac surgery is still ongoing (Rozental 2021).

Transpulmonary thermodilution (TPT) is an invasive tool that requires the placement of a central venous line (jugular or subclavian) and an arterial line (usually femoral, brachial or radial), that provides information on the macrohaemodynamic (cardiac output, systemic vascular resistances, volume statues, etc.) and respiratory status of the patient (extravascular lung water and pulmonary vascular permeability index). It is used in some ICUs or operating rooms for the management of complex patients (Monnet 2017). However, using it to guide haemodynamic management has not been shown to reduce mortality and only improves perfusion in hypotensive patients (Li 2021). There have been reports of thrombosis and other vascular complications due to the placement of arterial lines, in addition to the complications inherent to central venous catheterisation. More studies are required to elucidate the usefulness of invasive devices for haemodynamic monitoring in the ICU.

8. Malnutrition and Overfeeding

Patients with circulatory shock may benefit from short periods of fasting to avoid intestinal ischaemia while their macro- and microhaemodynamic status improves. Despite this, prolonged fasting and hospital malnutrition have been shown to be associated with poorer outcomes and higher mortality (Galindo-Martín 2018).

It is currently recommended to start with an enteral nutrition (EN) tolerance test at a trophic dose within 48 h of admission, aiming to cover 100% calorie requirement (20-30 kcal/kg/day) within 3-7 days of the onset of critical illness (ESPEN 2021). Starting EN with a full-dose calorie intake has not been shown to reduce mortality but can reduce the incidence of adverse events including gastrointestinal intolerance, episodes of hyperglycaemia, and increased insulin requirement (EDEN randomised trial 2012; EAT-ICU trial 2017). Low protein intake is associated with higher rates of infection and mortality in critically ill patients. Thus, it should be included in the nutritional intake (0.8-1.2 g Prot/kg/day). Intakes>1.2 g Prot/kg/day have not been shown to improve outcomes (Lee 2021; Hartl 2022). The cost of nutritional therapy, which may include calorie, protein, fat, or trace element supplements, must also be taken into account.

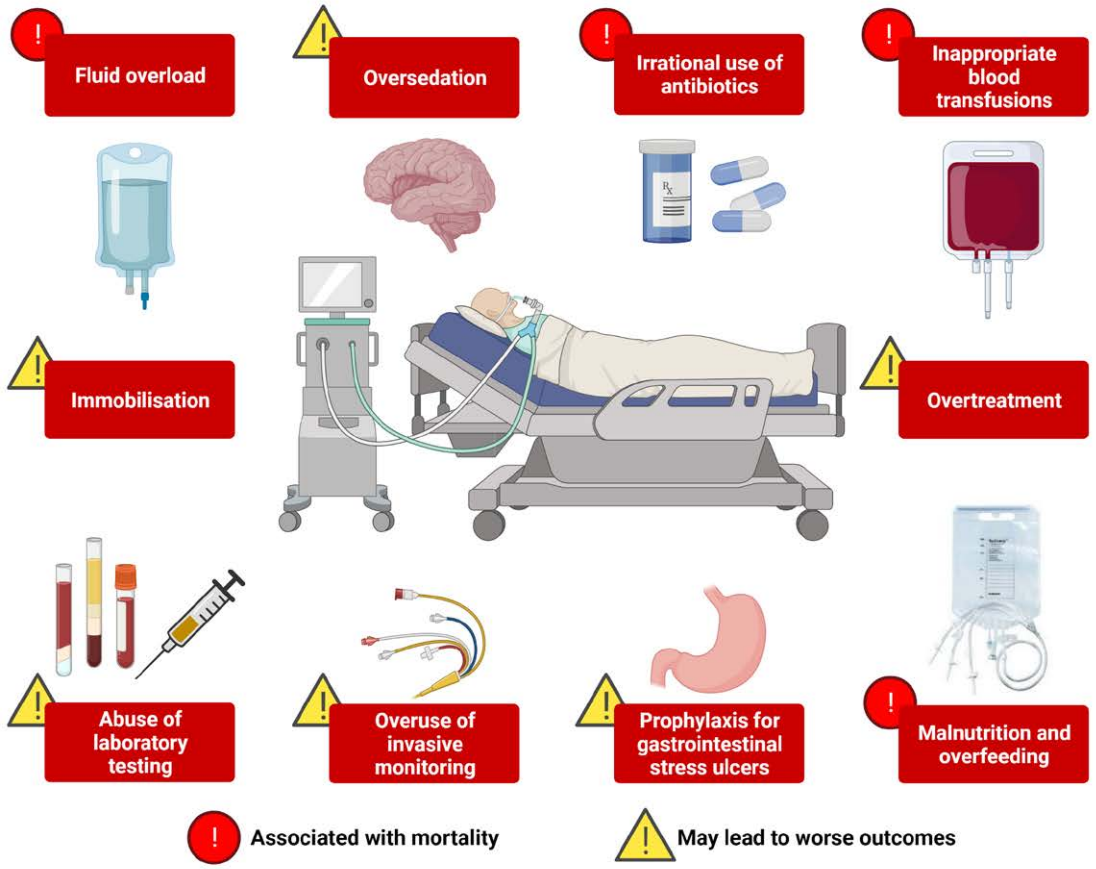

Figure 1. 10 common pitfalls in the management of critically ill patients

9. Overtreatment

Overtreatment includes performing interventions that are not desired by the patient and/or do not generate any benefit for the patient. Critically ill patients with chronic terminal illnesses or severe acute pathologies complicated by irreversible organ failure are often subjected to supportive therapies such as sedation, neuromuscular blockade, fluid therapy, vasopressors, inotropics, blood products, nutrition, antibiotics, and other drugs, which will not increase their chance of survival and will only increase days of hospital stay and inappropriate use of resources (lab and imaging studies, drugs, surgeries, etc.), including ICU admission itself (Druml 2019).

The following measures have been proposed for the prevention and recognition of overtreatment in the ICU: 1) Frequent evaluation of therapeutic goals within the medical team in charge, always taking into account the wishes of the patient and their family; 2) high quality multidisciplinary management; 3) minimise treatment costs and expenses; 4) strengthen multidisciplinary cooperation through education and training; and 5) promoting social discourse on overtreatment (Michalsen 2021). Humanisation and palliative care programmes should be implemented with the aim of relieving or reducing the patient's pain and suffering, without resorting to futile therapies.

"unjustified antibiotic prescription contributes to antimicrobial resistance, which is already a problem in most hospitals"

10. Immobilisation

Most critically ill patients remain immobilised, mainly when they are in IMV, shock or with severe neurological conditions. Prolonged immobilisation has serious consequences, such as weakness (polyneuropathy or myopathy), risk of venous embolism, pressure ulcers, etc. There is a widespread fear of frequent mobilisation, as it is commonly believed that a patient requiring vasopressor, mechanical ventilation, continuous renal replacement therapy or even ECMO should not be mobilised.

Rehabilitation should start in the ICU. The benefits of early mobilisation include improved muscle strength, increased patient independence, minimising the complications and risks described above, and favours domiciliary adaptation (Zhang 2019). It should be performed by trained physical therapy specialists and initiated when the patient is at minimal or no significant risk of complications, always following safety parameters, for which it is necessary to monitor vital signs, cardiovascular, neurological and respiratory status (Martinez-Camacho 2021).

Conclusion

The conduct of "doing more" in the management of critically ill patient does not always generate benefits and may carry risks. In the ICU, we must justify our medical decisions based on the best available evidence and only apply further therapeutic measures when improved outcomes have been demonstrated.

Conflict of Interest

None. ■

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Robert Shulman
Lead Pharmacist
Critical Care
UCLH NHS Foundation Trust Pharmacy Department
CMORE
University College Hospital
Honorary Associate Professor
UCL School of Pharmacy
Department of Practice and Policy
London, UK

robert.shulman@nhs.net

Processes to Reduce Medication Errors in the ICU

Medication errors are common in the complex environment of the ICU. This article provides an overview of the prevalence and impact of these errors and the processes that could help reduce their incidence.

Introduction

Medicines are the most widely used intervention in the critical care environment, and errors in medication use are a well-established complication. Medication errors have been broadly defined as any error in the prescribing, dispensing, or administration of a drug. Unlike adverse drug events which may be unpreventable, medication errors are considered preventable and may or may not have the potential to cause patient harm (Leape and Berwick 2005).

In general, medication errors occur at various stages of the medication management process as described in **Figure 1** (Elliott et al. 2021). This review will focus on the prevalence and impact of these types of error in the ICU and assess the processes that are designed to reduce the incidence.

Considering the nature of critical care, where patients require acute treatment often with multiple injectable medicines, it is unsurprising that medication errors are the commonest type of medical error encountered, accounting for 78% of serious medical errors (Rothschild et al. 2005). Most errors originate in the administration phase (Latif et al. 2013). A study of parenteral medication administration errors conducted over 24 hours in 113 intensive care units across 27 countries found that errors occurred at a rate of 74.5 events per 100 patient days (Valentin et al. 2009).

In the United Kingdom (UK), incidents involving medicines were the third largest group (nine percent) of all incidents reported to the national reporting and learning system. A detailed analysis of 72,482 medication incidents found the 100 most serious medication incident reports of death and severe harm were caused by errors in medicine administration (41%), followed by prescribing (32%). Of note, incidents involving injectable medicines represented 62% of all reported incidents leading to death or severe harm (Cousins 2007).

It is important to identify the stages at which the errors occur and the causative and contributory factors to develop preventative strategies and interventions. Many factors have been identified, including inadequate written communication (prescriptions, documentation, transcription), problems with medicines supply and storage, high perceived workload and patient acuity (Keers et al. 2013).

Prescribing

Instituting electronic prescribing (EP) in the ICU has had a profound effect on reducing medications errors. Many of the hospital-wide EP systems are not suitable for ICU use as they are not sophisticated enough to manage the continuous infusions that are commonly used. However these hospital-wide systems do have some excellent functionality e.g. allergy and drug interaction alerts, which many specific ICU systems lack. Many ICUs use the EP component of ICU clinical information management systems, without the basic functionality that is expected. There are now several electronic health records systems (EHRS) that include prescribing, notes and charting throughout the hospital. Whilst these may lack some of the functionality of a specific ICU system, they do benefit from the significant infrastructure underpinning the platform. A single hospital-wide EHRS eliminates transcription errors of prescribing when patients move in and out of ICUs.

In general, introduction of ICU EP system have led to a reduction in the medication error rate compared to hand-written charts (Shulman et al. 2005). But the types of error change with EP, leading to the introduction of new types of error which can be more serious than those seen with paper. EP does eliminate errors due to poor handwriting, abbreviations, non-approved drug names etc. It also provides decision support via the use of pre-written templates which can be set up to include key information that address common questions or scenarios and 'nudge' practice to approved pathways. This improves the consistency of prescribing and provides a means to control prescribing and administration practice throughout the day.

However the use of a stand-alone ICU system within a hospital produces significant problems of integration into the wider hospitals systems. Ward staff may be unable to access the ICU system and as such are 'locked out' by the technology, at odds from the concept of 'critical care without walls'.

Overall, the EP systems are beneficial but there are significant limitations which should be acknowledged and addressed by software manufacturers.

Systems that include decision support may add an additional layer of safety but there is an issue of 'alert fatigue' (Kane-Gill 2018). Work is ongoing to improve the specificity of alerts and machine learning (Syed et al. 2021) may help, as this field develops.

Specialist clinical pharmacists identify many prescribing errors in the course of their daily drug chart review. Their role is discussed further towards the end of this article. Pharmacist review is important is identifying prescribing errors. Decision support

within EHRS system can prevent unintended overdoses and guide dosing, but these systems can be circumvented by prescribers. Similarly, dosing needs to be optimised to the individual patient's requirements, which is beyond the capability of current systems and needs a specialist pharmacist to augment.

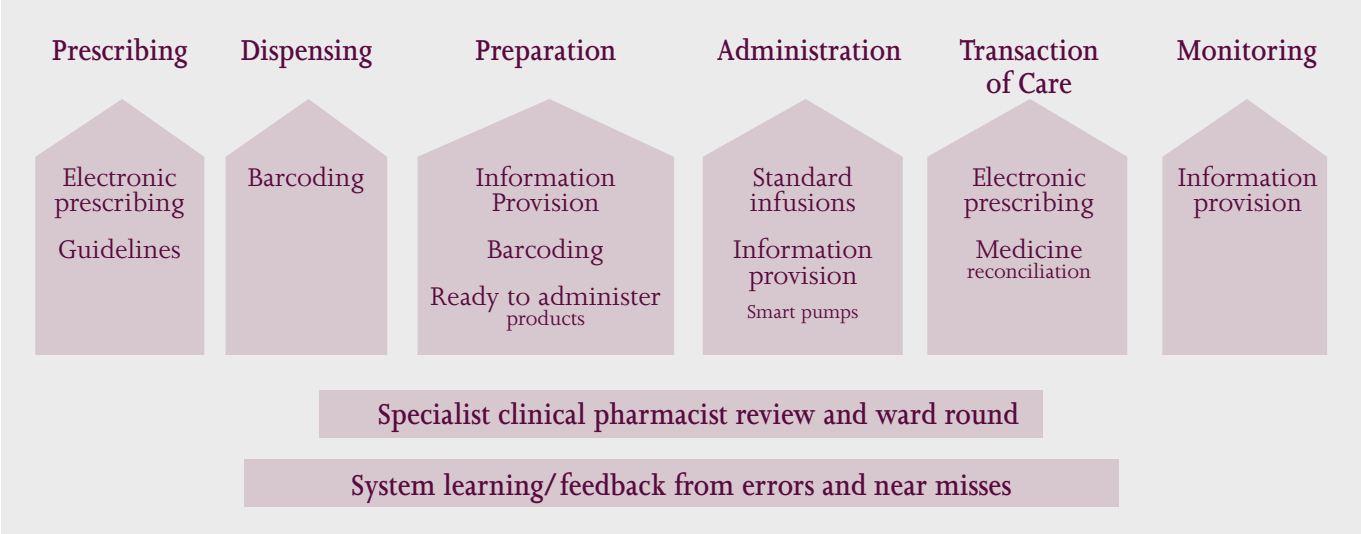

Figure 1. Medicines use stages and processes to reduce medication errors in the ICU

'Closed-unit' Prescribing in the ICU

ICUs are unusual within a hospital as the unit takes over the primary care of the patient once their healthcare needs cannot be met on a general or specialist ward. The primary team are no longer responsible for the day-to-day care of the patient, but their expertise is relied upon to advise on the specialist aspects of care. However the specialist practice may be at odds with ICU practice for example with regard to anti-infective length of course, dosing, or indeed initiation and deprescribing. Communication and collaboration is important between the teams, but some units do not allow the primary team to prescribe on the ICU. Running a 'closed unit' in this way, maintains an important principle that necessitates bedside communication as a requisite for changing the drug chart. In the absence of this, other teams can prescribe on the ICU without communication, and this may go against the overriding plans and unit guidelines. This lack of rigour can lead to medications errors, as the ICU may not fully understand the plan. This area of practice has not been researched but is a practical area which may impact on medications errors. An obvious exception to this will be the specialist prescribing of chemotherapy on the ICU. Here the ICU doctors do not have the necessary knowledge and competency to perform this safely.

Dispensing

These errors can occur in pharmacy but more commonly are related to 'picking' errors in the ICU. Most medications are supplied as stock in the ICU and there is a potential to select the wrong medication. The intervention aimed at reducing this is 'double-checking' with another co-worker before administration. This time consuming activity appears to detect some types of errors more than others (Douglass et al. 2018), in some cases the second checker may dissuade the first nurse from acting on the error!

An example of an ICU specific 'picking error' is the recurrently noted error of inadvertently hanging a glucose-containing infusion bag instead of saline for arterial line flushing. This can lead to misinterpretation of an apparent hyperglycaemia, leading to prescribing insulin therapy, causing a potentially dangerous hypoglycaemic episode (Gupta and Cook 2013). This error occurs despite the many systems in place and would benefit from an industry-led approach to 'engineer-out' this practice by having unique connectors between the arterial line and saline bag.

Barcode scanning of medication packaging may offer an effective safety mechanism for improving picking accuracy, though studies demonstrating this have not been published in critical care. Bar coding will only be functional where the outer packaging is intact, with an up-to-date bar code library linked to all the variety of products used, i.e. unusual medications, 'specials' or unlicensed medications may not have recognisable barcodes.

Preparation and Administration

Published evidence indicates that administration errors are more likely to occur with injectable medicines, notably the intravenous route (Keers et al. 2013). Errors are more likely to occur at the preparation stage (Leape and Berwick 2005), in administrations involving multiple steps and especially where there are interruptions or distractions.

Therefore strategies such as the provision of guidance on how to prepare and administer injectable medicines, use of 'do not disturb' tabards increasing nurses' awareness of risk factors involved through training and development programmes and effective second checking processes can be used to minimise these errors.

Smart Pumps Drug Libraries

There is an increasing trend towards better design of systems to limit the human factors that contribute to errors. For medication administration errors, "smart" infusion technology can provide this on a number of levels. Firstly, to enable set, pre-programmed rates of infusions, prescribing needs to be standardised. This reduces the variation in rates and ranges of intravenous medicine

prescriptions. The use of dose error reduction software, with the ability to set soft and harm limits can alert to prevent drug calculation errors, manual entry errors when entering dose or volume units or inadvertent pressing of buttons. Introduction can lead to a safe environment for IV administration (HSIB 2019) in ICU where complex infusion and injectable medicines are in high use. Smart infusion pumps have great potential to prevent prescribing as well as administration errors.

A systematic review (Ohashi et al. 2014) reported the benefits of smart pumps are intercepting errors (e.g., wrong rate, dose, or pump settings), reduction of adverse drug events, practice improvements and cost-effectiveness. Problems reported were lower compliance rates, overriding of soft alerts, non-intercepted errors and the possible use of the wrong drug library.

In practice, unless hard limits are activated, the safety benefits may not be seen (Trbovich et al. 2010). A recent national report highlighted that their introduction can introduce new risks (HSIB 2019). Software is needed to upload the drug library to smart pumps, download data logs (including any errors detected) and monitor the status of each smart pump. Maintaining the required IT infrastructure requires specialist staff roles and often a new skill set.

Ready to Administer Injectables

There are a variety of intravenous (IV) syringe concentrations used throughout the various ICUs, having evolved through custom and practice. With the movement of staff from one unit to another it is desirable to standardise IV infusions, where possible. There is evidence that the manual preparation of syringes on the ICU can vary significantly from what was intended (Dehmel et al. 2011; Adapa et al. 2012). A list of standard syringe concentrations have been published in the UK (ICS and UKCPA CCG 2020). Several manufacturers have launched pre-filled syringes or 'ready to administer' vials to correspond with these concentrations, with the intention of reducing the number of manipulations by staff and reducing the likelihood of error. This approach is in accordance with the NPSA alert 20 (NPSA 2007) which stated that, particularly for high risk drugs, hospitals should look for ways to minimise the number of manipulations involved in preparing the product for administration. The drive for standardisation has been helped by the parallel move towards electronic prescribing systems which have templates of standard prescription concentrations and the adoptions of smart pumps with drug libraries (both of which are discussed separately in this article).

> **"medication errors are the commonest type of medical error encountered, accounting for 78% of serious medical errors"**

However there is a cost implication of adopting these products, which may be offset to an extent by savings in nursing time and reductions in errors. Ready-to-use products require additional space, more attention to ordering and stock rotation to avoid expired stock.

Transition of Care

In a systematic review, Bourne et al. (2022) highlights that the protracted recovery of ICU patients may be further compounded by polypharmacy and care fragmentation. Frequent medication changes, with many chronic medicines discontinued and acute medication commenced, present a patient safety concern, particularly at the point of transitions.

Medicine Reconciliation

The aim of medicines reconciliation in ICU is to ensure that medicines prescribed on ICU admission (if still appropriate) correspond to those that the patient was taking pre- admission. In a previous era, perhaps this was not considered a high priority in the ICU, as the focus was more on the acute aspects of critical illness. It is now recognised that the ICU admission can have a great influence on future drug treatment. Research has showed that medications not prescribed in the ICU, can continue to be omitted on the ward and in some cases on hospital discharge (Eijsbroek et al. 2013). Research indicates that 60-75% of chronic medications are stopped on ICU admission (Campbell et al. 2006) and 80% not restarted on ICU or 30% on hospital discharge (Bell et al. 2006).

Sudden discontinuation of antidepressants such as paroxetine can cause withdrawal phenomena which can contribute to ICU delirium. Omitting to prescribe chronic thyroid replacement therapy in ICU has been associated with negative clinical outcomes (Barrett et al. 2012).

Medication reconciliation on ICU admission is routine in the UK, often carried out by Medicine Management Pharmacy Technicians. Discharge reconciliation at ICU discharge is less widespread, though is equally important. Barriers to this include delayed discharges which are suddenly actioned without an effective review. Good discharge reconciliation would include documentation for the receiving team any changes to the chronic medication and the ongoing plans for newly introduced medication, for example for insomnia, delirium, atrial fibrillation and corticosteroids.

The evidence currently shows that multicomponent interventions based on staff education and guidelines increase de-prescribing of inappropriate medication at patient hospital discharge by nearly four times (Bourne et al. 2022). Further research is required to establish a process to anchor a quality medication review/communication at ICU discharge.

Discharge Home from the ICU

The ICU can be a less safe zone when unusual practices are undertaken, even though these can be routine on the general wards. Examples of ICU patients who may go home directly from the ICU include some palliative care patients, self-discharges or short-stay post-op recovery patients. These can be complex discharges where the patient and GP need effective communication to manage detailed thrombosis management plans (which may include arranging anticoagulant follow-up clinics), communication with drug addiction services in the community and a phased reintroduction of chronically used medications. This is outside the comfort zone of many ICU practitioners, but these skills and practices need to be mastered in order to execute these important general ward roles safely.

Monitoring

Guidelines

A suite of local and accessible guidelines can help ICU staff to safely and consistently administer complex and potentially harmful therapy. Easy access to resources such as prescribing guides and local guidelines are likely to reduce prescribing errors. The critique of this approach is that it may detract from individualised medicine (Vincent et al. 2021). But it does at least default practice to a good basic standard, that experts can depart from if the occasion requires.

Miscellaneous

Clinical Pharmacists

The pharmacist's key role is to promote pharmacotherapy for patients that are safe and effective. Their contribution in critical care has been shown to reduce mortality, length of stay and preventable and non-preventable adverse events (Lee at al. 2019). They influence medication safety across all the stages of medicines use.

The ICU specialist clinical pharmacist (SCP) in the UK are well established members of the multi-disciplinary team. The Core Standards for Intensive Care Units (GPICS 2019) recognises that the ICU pharmacist should have competency in critical care, and the requisite number of SCPs are necessary relative to the size of the unit and the acuity of the patients.

The PROTECTED-ICU UK study report that SCPs made a clinical contribution in 1 in 6 prescriptions on weekdays but 1 in 3 on weekends (Shulman et al. 2015; Rudall et al. 2017). In the 925 patients' medication reviewed over a 14 day period, 1,393 medication errors were detected. Of these 43% were of moderate impact and 19% were high impact. The types of errors noted in order of prevalence were drugs that were needed but were not prescribed, drugs prescribed that were no longer needed, too high/low doses, error of monitoring and drug interactions/incompatibility. The results showed that 8% of all prescriptions had a medication error which was identified and corrected by the SCP. Of these 19.0% were designated as 'high' impact, had they been administered as prescribed and 42.6% were of 'moderate' impact. Not surprisingly more experienced SCPs provided clinical contributions that had a higher impact than their junior colleagues. This data provides good evidence that SCP play a vital role in detecting and resolving medication errors.

> **"multicomponent interventions based on staff education and guidelines increase de-prescribing of inappropriate medication at patient hospital discharge by nearly four times"**

Learning Environment

Learning from critical incidents is an important element to improve the safety in the ICU. Interdisciplinary review of medication events (Chapuis et al. 2019) can lead to a richer understanding of the contributory factors and to more effective solutions, introduced by those with a good understanding of the issues, with the power and motivation to introduce change. System learning and feedback to staff are also important to provide a safer environment for our patients.

Conclusion

Medication errors are common in the complex environment of the ICU. Each unit will need to embrace a bundle of measures to minimise these errors. The key strategies are discussed in this article. Continuous review of safety is important and also a recognition that an error without a patient consequence should be viewed as an opportunity to learn lessons and implement changes to help minimise the likelihood of more serious events in the future.

Conflict of Interest

None. ■

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For full references, please email editorial@icu-management.org or visit https://iii.hm/1ecf

Fredrik Olsen
Department of Anesthesiology and Critical Care
University of Gothenburg and Sahlgrenska University Hospital/Mölndal
Gothenburg, Sweden

Postdoctoral research fellow
Department of Anesthesiology
Atrium Health Wake Forest Baptist Medical Center
Wake Forest School of Medicine
Winston-Salem, NC
USA

folsen@wakehealth.edu

Ashish K Khanna
Associate Professor and Vice-Chair for Research
Department of Anesthesiology
Section on Critical Care Medicine
Atrium Health Wake Forest Baptist Medical Center
Wake Forest School of Medicine
Winston-Salem, NC

Outcomes Research Consortium
Cleveland, OH
USA

akhanna@wakehealth.edu

Monitoring Postoperative Hypotension – A Futuristic Look at Patient Safety

Post-operative hypotension is a frequent occurrence that is unrecognised with intermittent spot checks based monitoring in most hospital ward patients. Myocardial injury is strongly associated with hypotension in this period of recovery from surgery. Upgrading ward monitoring to portable, smart, and continuous systems with effective alarm management and efficient response systems is the need of the hour. It is evident that the near future will provide a continuum of connected care via ongoing monitoring that extends across the perioperative period and goes home with the patient.

Introduction

While we have improved intra-operative outcomes, our patients continue to suffer harm in the postoperative period. The 30-days after non-cardiac surgery is a major cause of death in the United States and the world over (Bartels et al. 2013). Around 70% of these deaths occur before patients go home, during initial hospitalisation in the postoperative period and while they recover in our best hospital systems. Importantly, approximately one-half of all these adverse events occur in the relatively under-monitored hospital ward environment (De Vries et al. 2008; Pearse et al. 2012; Andersen et al. 2016). Most important contributions to post-operative patient mortality come from sepsis, major bleeding, and myocardial injury (Spence et al. 2019). Of these, intra and postoperative hypotension are strongly associated with myocardial injury, renal injury, and death (Walsh et al. 2013; Mascha et al. 2015; Salmasi et al. 2017; Sessler and Khanna 2018; Liem et al. 2020; Gregory et al. 2021; Khanna et al. 2021). The relationship of post-operative hypotension (POH) with myocardial injury appears more robust than intraoperative hypotension (IOH) (Sessler and Khanna 2018; Sessler et al. 2018; Liem et al. 2020; Khanna et al. 2021). POH is also strongly associated with several serious and costly adverse outcomes such as death, increased hospital length of stay, prolonged critical care needs, delirium, and kidney injury (Smischney et al. 2020; Khanna et al. 2021).

During surgery we monitor frequently (typically at least once every five minutes) for hypotension and blood pressure fluctuations according to standards set by the American Association of Anesthesiologists (ASA). The standard non-invasive technique for BP monitoring is the upper arm cuff auscultatory method developed by Korotkoff (Paskalev et al. 2005). Arterial cannulation is the usual gold standard for beat-to-beat and invasive blood pressure monitoring, that detects at least two times as much hypotension as intermittent cuff monitoring in the intra-operative environment (Naylor et al. 2020). Substantial new data has emerged that proves accuracy and validation of non-invasive and portable alternatives for arterial lines (Martina et al. 2012; Ameloot et al. 2013; Gratz et al. 2017; Tanioku et al. 2020; Kwon et al. 2021). Consequently, the scope of accurate blood pressure monitoring, and prevention of harm related to haemodynamic changes is now extending beyond the traditional confines of the operating room, the post-anaesthesia care unit, and the intensive care unit.

Haemodynamic monitoring for patients during immediate postoperative recovery in the PACU is frequent as well and may include for some, a more enhanced monitoring phase in the ICU. However, this monitoring standard drops off rapidly as patients are transitioned to hospital ward care where at best vital signs are checked every once in 4-8 hours (Khanna et al. 2019; Turan et al. 2019). This leaves the patient unmonitored for most of the hospital stay after surgery (Sessler and Saugel 2019; Khanna et al. 2021). A wrong yet tempting assumption here, is that with increased time after surgery and delivery of anaesthesia there is a reduced risk of influencing the patient's cardiovascular or respiratory homeostasis and that most patients are on track to normal physiology and an uneventful clinical recovery.

Adverse cardiorespiratory events occur commonly on hospi-

tal wards, importantly most do not occur suddenly, instead are preceded by hours of progressively more abnormal vital signs (Andersen et al. 2016) Because vital signs are measured intermittently, postoperative blood pressure and heart rate perturbations are often sustained for long periods without recognition (Turan et al. 2019) However, published studies have been small, restricted to selected populations, and involve blinded clinicians to supplemental monitoring. We as yet miss an adequately powered randomised trial to test the influence of postoperative hypotension monitoring on patient centric outcomes (Andersen et al. 2016; Turan et al. 2019; Weenk et al. 2019, 2020; Liem et al. 2020).

Building a Continuous Monitoring System on Hospital Wards

Some important questions need answered as we build an effective continuous blood pressure monitoring system for the hospital ward. There are many proposed definitions of hypotension or what is constituted as clinically relevant low blood pressure in the postoperative patient. While several different thresholds of blood pressure and components have been investigated, a question that remains yet to be answered for hospital ward patients is, if there is an absolute blood pressure level, or a relative blood pressure compared to a (mostly unknown) baseline blood pressure that is more critical to outcomes. Most commonly, during the intra-operative period an absolute level of 65mmHg of mean arterial pressure (MAP) is a widely accepted level whereas another definition is 30% below baseline MAP, both of which appear to have a similar risk (Salmasi et al. 2017). This threshold for the hospital ward patients seems somewhat higher at a MAP of 75 mmHg (Liem et al. 2020; Khanna et al. 2021). Do we view hypotension as a singular insult or a cumulative burden with a dose dependent effect on organ damage? While most of the published thresholds have been established with frequent intra-operative blood pressure data, it is difficult to replicate the same experiments, with a normal ward monitoring regimen as intermittent spot checks are far too interspersed to translate into a cumulative effect (Khanna et al. 2021).

Perioperative hypotension is associated with increased healthcare resource utilisation (Stapelfeldt et al. 2021). The degree of monitoring a patient receives, reflects the perceived level of risk during the postoperative setting and is subject to a cost-benefit evaluation. One can expect the level of risk for adverse haemodynamic events to be inversely proportional to the time elapsed from surgery as the patient returns to a baseline physiology without the need for haemodynamic monitoring. As the factors in the cost-benefit equation differs so should the result of the decision of how patients are monitored. Less risk aversity would imply a higher benefit in the equation. In addition, public trust in healthcare systems is important and avoidance of adverse events are critical to build that trust. Furthermore, the development of new and accurate, well validated technologies for patient monitoring would relieve the nursing staff of manual BP measurements (and other vital signs checks). Therefore, it is very much possible to introduce more portable continuous automated monitoring systems on hospital wards, along with increased acceptance and adoption of technology and gradually decrease staffing needs. Hospital systems administrators need to understand that while there is an initial cost to implement continuous monitoring, this is soon offset with a very minimal and largely attainable decrease in adverse events (Khanna et al. 2021). Knowing how common myocardial injury is in the post-operative period and its very strong association with hypotension, a breakeven point on investment in continuous portable haemodynamic monitoring would be easily attainable in a short period of time post implementation. From that point onward, improved patient safety, less organ system injury, decreased hospital length of stay, and most importantly improved provider and patient or patient family satisfaction would drive further adoption. The most important piece in this futuristic look is the acceptance of new technology by bedside providers which will necessitate better alarm management, understanding artefacts, improving protocol-based management for haemodynamic instability, and developing platforms that act as central monitoring stations with an effective 'efferent arm'. The role of artificial intelligence will be more important as we build a preventive and predictive arm to hypotension on the general hospital care floor as well.

> **"perioperative hypotension is associated with increased healthcare resource utilisation"**

Real World Postoperative Hypotension Monitoring Data

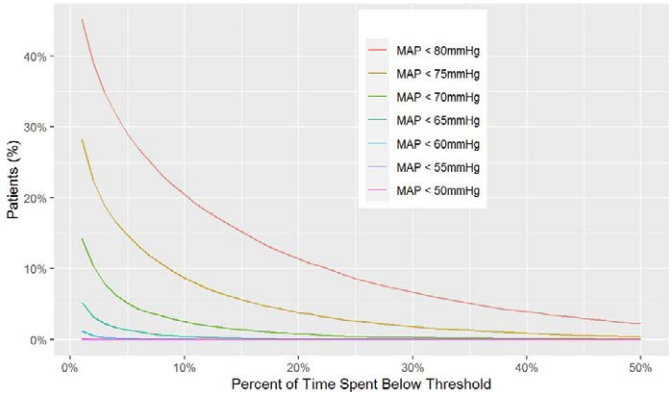
At the Atrium Health Wake Forest Baptist Medical Center part of the Wake Forest University School of Medicine, we have used continuous portable vital signs monitoring systems on our general hospital wards for about the last five years. Here, we record blood pressure and heart rate at 15-second intervals using a wireless non-invasive monitor in adults recovering from noncardiac surgery. For monitoring, we use a portable wrist mounted system that is cleared by the United States Food and Drug Administration. The system includes a 3- or 5-lead electrocardiogram and an oscillometric blood pressure monitor which is used to calibrate the continuous non-invasive blood pressure monitor at least once daily. Continuous blood pressure is estimated from pulse arrival time, specifically the time that elapses between R wave being detected and arrival of the resulting pulse at the SpO_2 finger sensor.

Based on several alarm simulation studies, we currently have the monitor generate nursing alerts for haemodynamic events defined by heart rate >150 beats/minute or <39 beats/minute, systolic blood pressures >200 mmHg or <80 mmHg and mean arterial pressures (MAP) <58 mmHg. These settings have allowed us to capture significant vital signs disturbances while limiting alarm fatigue. Nurses are encouraged to intervene when clinically indicated and have an escalating system of networked alarms. The monitors are calibrated at least daily and connected to the hospital's wireless network. Vital signs abnormalities exceeding established thresholds generate alerts that are distributed to

a central station and to the nurses' hospital-supplied phones. Alarms that are not addressed by the primary nurses within a few minutes are escalated to other floor nurses, and thereafter to the unit manager.

Our recently analysed data sample contains 82715 monitoring sessions across 31587 patient visits among 28108 total patients (Unpublished data - Khanna and colleagues). While our hospital wide continuous and 'closed loop' monitoring systems achieved better results than previously published small datasets with blinded monitoring (Turan et al. 2020), we still see significant hypotension that is picked up by continuous monitoring that would have gone unrecognised with intermittent monitoring. **Figure 1** shows percentage of patients by time spent hypotensive across varying defining thresholds; here roughly 20% of our patient population spent at least 10% of their time hypotensive defined conservatively by MAP < 80mmHg. Slightly fewer than 10% of patients spent at least 10% of their time with MAP < 75mmHg, and fewer than 5% of patients spent at least 10% of time spent with MAP < 70mmHg.

Assessing **Figure 2**, we see the relationship of continuous minutes of monitoring time spent under blood pressure thresholds for proportions of monitored patients. We had approximately 34% of patients spend at least one minute with MAP ≤ 70mmHg, and another approximately 20% of patients who spent at least five continuous minutes with MAP ≤ 70mmHg. The 'Intermittent Detection Incidence' (dashed line) closely follows the line representing the incidence rate of patients with hypotension defined by sustained periods of time > 30 minutes for each threshold. This suggests that intermittent patient assessments every four hours would capture about the same amount of hypotensive episodes as continuous monitoring when a hypotensive episode is defined as spending at least 30 minutes below a given threshold.



Interpretation: Each line represents the Y% of patients (Y-axis) that spent X% of time (X-axis) under the specified MAP threshold given by line color. I.e. Looking at the red line which corresponds to MAP <80, we see that approximately 20% of patients (y-axis) spent 10% of time (x-axis) under the thershold MAP <80. Similarly for the yellow line (MAP <75), we see that 10% of patients spent about 10% of time under the threshold MAP <75.

Figure 1. Post-operative hospital ward patients and hypotensive thresholds as a percentage of time below thresholds

Existing Technologies

Pulse Wave Velocity (PWV) measures time delay of a pulse wave from its origin in the heart, defined by the ECG signal, and its detection at the finger through a pulse oximetry reading (Rastegar et al. 2020; Senturk et al. 2020). Derivation of blood pressure from the time delay between ECG and plethysmograph is more complex than a simple correlation. Algorithms that consider signal quality, artefacts and perfusion are in place to convert a measurement of time delay to one of pressure. These algorithms have been trained on large ICU datasets such as the Medical Information Mart for Intensive Care (MIMIC-II) (Senturk et al. 2020). Studies comparing the technique with a cuff-based technique and arterial line have shown good calibration (Watanabe et al. 2017; Hill et al. 2021) while validation against an invasive arterial line appears to be lacking (Hill et al. 2021). In theory, several modalities can be used to collect proximal and distal waveforms, such as speckle plethysmogram, impedance plethysmogram or mechanical pulse wave (Le et al. 2020; Pielmus et al. 2021). Pulse wave velocity or pulse arrival time systems have been implemented clinically with good results and with minimal alarm fatigue at some healthcare systems in the United States including ours (Weller et al. 2018). We report some of the processed data from several thousand patients at our healthcare system in the previous section.

Pulse wave decomposition is another established method that relies on a morphological analysis of the plethysmograph wave form. This may be in effect an advancement on pulse contour analysis of the arterial wave form established in critical care (Baruch et al. 2014; Pielmus et al. 2021). The method itself is based on breaking down the plethysmograph waveform into its different components and analysing them both individually and as a composite measure based on relative size and time delay at the sensor level. After calibration, this method delivers a reliable blood pressure reading validated against an intra-operative radial arterial cannulation (Gratz et al. 2017; Kwon et al. 2021).

Volume clamp method relies on a finger cuff that is continuously inflated to keep the artery at constant size as measured by the absorption of light. The pressure delivered is used as a basis to estimate pressure at the level of the brachial artery. This system has excellent validation data and as well as data that has shown an increase in detection and a decrease in overall hypotension (more corrective measures as detection increased) when used in the operating room compared to standard intermittent cuff based measures (Martina et al. 2012; Maheshwari et al. 2018; Tanioku et al. 2020).

Optical pulse wave analysis technology is analogous to pulse wave decomposition but uses a photo plethysmography wave form as its input. A bracelet housing the optical emitter and sensor is worn on the wrist. Systems that are available have shown good calibration in recent studies (Nachman et al. 2020; Vybornova et al. 2021).

Newer Technologies

Artery applanation is based on an automation of the clinical practice of palpating a pulse at a convenient location such as the radial artery at the wrist. A highly sensitive pressure transducer converting the minute mechanical energy to an electric signal complete with waveform is achieved. It is however sensitive to sensor placement and movement artefacts

(Földi et al. 2018). Current iterations are bulky and not in routine use, but there is work being done to miniaturise the technology.

Continuous wave (CW) doppler ultrasound patches that measure flow velocity over the carotid artery are under development and show promising results (Kenny et al. 2021). By attaching this device over the carotid artery and keeping it in place with an adhesive, a CW doppler signal can be collected continuously and haemodynamic data can be extracted.

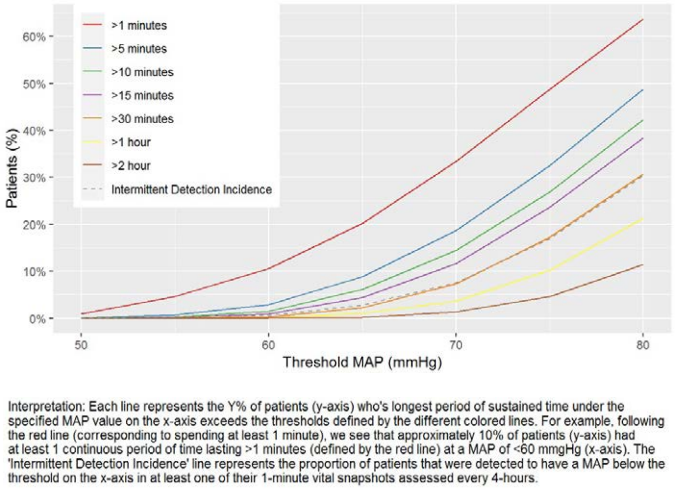


Figure 2. Post-operative hospital ward patients and continuous periods of monitoring time below hypotensive thresholds

Electrical conductance of the thorax is associated with the proportion of fluid it contains. As pulsatile blood flow is the dominating source of fluctuation of fluid volume there is an association between blood flow in the thorax and the measured conductance. Further research is warranted for these to be used as long term portable monitoring (Nguyen and Squara 2017).

Electrical cardiometry derives cardiac output and thereby blood pressure from measuring electrical impedance changes from orientation of red blood cells in pulsatile flowing blood. This is achieved through a series of electrical sensors on the thorax, neck, and thigh (Sanders et al. 2020).

> **alarm fatigue is a real threat as well as the need to detect technical issues and disconnections**

A Look to the Future

The availability of wireless continuous blood pressure monitoring devices is increasing. Several systems are in place using different technological approaches. A higher level of haemodynamic monitoring of patients after surgery extending beyond the PACU and ICU seems inevitable. A culture change that will necessitate increased accountability and responsibility for correction of haemodynamic changes using higher intensity monitoring is necessary and has already begun. The future of monitoring will take it beyond the hospital and home with the patient. Several interesting questions need answered. How do we build effective closed loop continuous monitoring systems on hospital wards with minimal alarm fatigue, best provider, and patient acceptance as well as a maximal decrease in adverse events? How do we take the patient from continuous ward monitoring to no monitoring whatsoever on hospital discharge? Will the transition from continuous monitoring in the hospital to home monitoring mean 'less-frequent' continuous monitoring as a 'weaning' mechanism? Will postoperative monitoring at home have a central monitoring system and be linked to billable hospital services for providers? Will it influence us to discharge patients earlier from the hospital after surgery or will we paradoxically keep patients in the hospital longer because we detect more changes in vital signs with a higher level of monitoring? As monitors move from direct measurements to derived values, often with the help of advanced algorithms, there arises a need to 'monitor the monitors'. Alarm fatigue is a real threat as well as the need to detect technical issues and disconnections. By integrating a huge number of datapoints, the possibility of automating early warning scores seems natural and necessary. Beyond digitising and automatisation of existing early warning scores, there is the possibility to use continuous streaming physiological vital signs data patterns to make real-time predictions for clinical outcomes and events. A set of haemodynamic parameters can potentially dynamically be analysed not as a selection of individual values but in relation to each other. Here a set of measurements that each in their own is within normal range can still potentially signal an impending deterioration.

As is the case with many emerging technological advances in the field of anaesthesia and critical care, this field is also driven by the advent of artificial intelligence (AI) or machine learning. It is the possibility of taking large amounts of data and developing algorithms correlating the current state input signal to an estimation of haemodynamic compromise in future. Artificial intelligence is also needed to determine if an out of bounds measurement is due to a clinically important haemodynamic change or the result of a technical issue. Given the enormous amounts of data our patients generate in the peri- and postoperative setting, AI is taking on a greater role in helping clinicians be aware of significant clinical developments at the same time shielding them from sifting through large amounts of noisy data.

Predicting new technology is difficult; however we can be certain that existing ward monitoring technology will be refined, and hardware will be further miniaturised and ultimately there will be universal adoption and growth to improve patient safety outcomes. With growing interest in self-monitoring, it is also likely that perhaps the consumer and asks from our hospitalised patients will lead the way forward in the next five years. A well designed, appropriately powered large randomised trial with the right outcomes will most certainly be that landmark paper that will place continuous blood pressure monitoring on floor patients as part of guidelines documents.

Conflict of Interest

Dr Olsen has no conflict of interest to report. Dr Khanna consults for Edwards Lifesciences, Philips North America, GE Healthcare, Hill-Rom, Potrero Medical, Retia Medical and Caretaker Medical. His institution has current and recent grant funding from Edwards Lifesciences, Caretaker Medical, Potrero Medical and Retia Medical for ongoing investigations on portable monitoring. Dr Khanna is on the executive advisory board for Medtronic. He receives support from the Wake Forest CTSI via NIH/NCATS KL2 for a trial of continuous portable haemodynamic and saturation monitoring on hospital wards. Dr Khanna is a founding member of the BrainX group that conducts education, research, and collaboration on AI techniques in healthcare and has a commercial arm at www.BrainXAI.com. ■

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Marian Altman
Clinical Practice Specialist
Practice Excellence Department
The American Association of Critical-Care Nurses
Richmond, VA, USA

marian.altman@aacn.org

Debbie Brinker
Clinical Practice Specialist
Practice Excellence Department
The American Association of Critical-Care Nurses
Spokane WA, USA

debbie.brinker@aacn.org

Nurse-Driven Initiatives Impact Patient Safety

This article highlights the effects of the COVID-19 pandemic on patient quality and safety and discusses an academy designed to support nurses to design and implement innovative solutions.

Introduction

The COVID-19 pandemic has heightened the crisis of patient safety with an increase in hospital-acquired conditions (HACs) after more than five years of declining incidence (Weinter-Lastinger et al. 2022). Hospital patient satisfaction scores rose at the beginning of the pandemic, but are now plummeting (Press Ganey 2021). In December 2020, the American Nurses Foundation shared the findings of the Pulse of the Nation's Nurses Survey, reporting increased levels of nurse stress, exhaustion and burnout with 21% of nurses stating they intend to leave their position and 29% stating they may leave (Hanley 2021). Also, in a recent American Association of Critical-Care Nurses (AACN) survey, 92% of 6,000 nurses responded that they believe their careers will be shorter because of their COVID-19 experience, with 66% reporting they were considering leaving the profession as a result (American Association of Critical-Care Nurses 2021). This "perfect storm" begs for change leadership strategies to address the issues, and direct care nurses (DCNs) have a history of being innovators at the bedside. This article will highlight the effects of the COVID-19 pandemic on patient quality and safety and discuss a hospital-based direct care nurse academy designed to support nurses to design and implement innovative solutions addressing medical errors, HACs and patient safety led by DCNs through the AACN Clinical Scene Investigator (CSI) Academy.

Background

The push to ensure quality of care and safe passage for patients began in earnest in 2000 with the Institute of Medicine's (now National Academy of Medicine) "To Error is Human" report breaking the silence about medical errors. Patient harm during healthcare is a leading cause of morbidity and mortality internationally (Elder and Dovey 2002). The World Health Organization defines patient harm as "an incident that results in harm to a patient such as impairment of structure or function of the body and/or any deleterious effect arising there from or associated with plans or actions taken during the provision of healthcare, rather than an underlying disease or injury, and may be physical, social or psychological (disease, injury, suffering, disability and death)" (World Health Organization 2009). Patient harm that occurs as a result of a modifiable cause can be avoided by adapting processes, and implementing and adhering to guidelines. Prior to the pandemic, hospitals implemented evidence-based practices that reduced hospital acquired infections as well as other quality improvement (QI) activities to address HACs. DCNs are instrumental in leading these improvement efforts, as they intricately understand the complexities of patient care and they can identify problems and solutions to address patient safety and prevent medical errors (Schatz 2021).

COVID-19 Impact

The COVID-19 pandemic has greatly impacted healthcare systems. The pandemic has caused surges in hospital admissions of patients with high acuity and a greater length of stay. Hospitals scrambled to react with increases in bed capacity, particularly intensive care unit (ICU) beds. They increased staff-to-patient ratios, reorganised care delivery and implemented crisis standards of care. The pandemic also caused significant supply chain shortages in a wide variety of materials and products, but especially those related to personal protection equipment. These factors may have contributed to the significant increases observed for central line-associated bloodstream infections (CLABSIs), catheter-associated urinary tract infections (CAUTIs), ventilator adverse events (VAEs), methicillin resistant staphylococcus aureus (MRSA) bacteraemia, and device utilisation of central line, urinary catheter and ventilators compared to 2019 (Centers for Disease Control and Prevention 2020). In addition, hospitals are realising the pandemic's impact on the quality of nursing care.

Although the pandemic has illustrated the importance of acute and critical care nursing, the visibility of pre-pandemic workforce challenges has been heightened, and it has also adversely affected healthcare workers. Staff shortages that were present prior to the pandemic have been exacerbated by it, with high turnover rates, high vacancy rates, retirements, increased reliance on travel nurses and changed employee expectations (Avant Healthcare Profes-

sionals 2021; NSI Nursing Solutions 2021; O'Boyle 2021). Many organisations implemented the use of alternative nurse-to-patient ratios, as well as the deployment of nonacute care nurses in the acute care setting (Grimely et al. 2021). Healthcare workers are exhausted as a result of continued surges, higher patient acuity, increased mortality and continuous staffing shortages. These factors have resulted in the "great resignation" with healthcare workers leaving their current position or even the profession and have contributed to the increase of HACs.

Strategy: Nurses Leading Change

The 2010 and the "2020-2030 Future of Nursing: Leading Change, Advancing Health" reports recommended expanding opportunities for nurses to lead improvement efforts and, specifically, prepare and enable nurses to lead the change needed to advance health. All nurses are in an exclusive position as the healthcare provider closest to the patient 24/7. Nurses, the largest segment of the healthcare workforce, are vital to keeping patients safe from harm. This, along with nurses' education and leadership abilities, suggests that nurses should be the drivers of change to improve the healthcare system. In addition, the literature supports that engaging DCNs in improvement projects has resulted in positive patient, nurse and organisational outcomes, including decreased nurse stress and increased communication and collaboration (Moore and Stichler 2015; American Organization of Nurse Executives). Similarly, nurses are in a unique position to advance the Quadruple Aim by: 1) improving the patient experience of care (including quality); 2) improving the health of populations, 3) reducing the per capita cost of healthcare and; 4) improving the culture and health of the unit impacting DCNs' work lives and satisfaction with their jobs.

Traditionally, QI projects are generated and diffused in a top-down approach and may or may not include DCNs in their design, yet these nurses are held accountable for the implementation and outcomes. It is essential that nurses, now more than ever, be at the forefront of creating practical and positive change (Schatz 2021). DCNs are leaders uniquely positioned to identify patient care and QI problems and develop innovative solutions. DCNs are ideally suited to also drive change to improve healthcare workplaces, leading to healthier collaborative work teams while improving the culture (Bowers 2021).

> **"nurses, the largest segment of the healthcare workforce, are vital to keeping patients safe from harm"**

Clinical Scene Investigator (CSI) Academy

Recognising the untapped power of DCNs to drive meaningful change, AACN created a nationwide DCN change leadership programme in 2012, called AACN Clinical Scene Investigator (CSI) Academy. The programme aims to help nurses influence positive change in patient care and their work environment. The AACN CSI Academy is a 12-month, hospital-based, project-driven nursing innovation and leadership education programme designed to empower DCNs as clinician leaders and change agents whose initiatives improve both patient and fiscal outcomes. At its core, AACN CSI Academy leverages the staff nurse's expertise to enhance patient care, supporting that expertise with additional leadership skills gained through team education, coaching and mentoring.

AACN believes that DCNs are critical players in creating lasting change and, ultimately, transforming healthcare. The goal of AACN CSI Academy is to provide staff nurses with the knowledge and support necessary to become leaders guiding their peers to create unit-based sustainable change, easily scaled hospital-wide for the most significant impact.

Curriculum

Hospitals engage unit-based teams of two to four DCNs to work with AACN CSI Academy faculty and an internal mentor to identify current patient-care challenges in their unit that fall within the nursing sphere of influence, then develop, implement and evaluate solutions intended to achieve measurable and sustainable clinical and financial improvements. Participants meet monthly with faculty who provide content in an iterative manner. The programme curriculum consists of content delivered in an experiential learning environment, including on-site workshops, interactive online learning and regular consultation in-person, by phone and via email. Key curricular concepts include leadership, QI processes, project management, business case for quality, change strategies such as social entrepreneurship, data collection and analysis, QI processes, and stakeholder engagement with an emphasis on strategic communication. Participants are given dedicated nonproductive or indirect care time to work on the projects each month and apply the content provided in the previous month's meeting. This dedicated project time is essential to enable nurses to lead change, to keep the projects moving forward and it leads to undeniable positive patient and clinical outcomes contributing to the primary mission of patient care and advancing nursing practice (Altman and Rosa 2016). The amount of monthly time needed varies from eight to 12 hours per month per team member. The DCNs demonstrate the components of innovative project management while creating the change needed for improvement in the quality of care and better outcomes.

Programme Outcomes

To date, 469 DCNs from 127 units representing 82 hospitals across the United States have participated in the programme. DCN teams report decreases in hospital acquired infections such as CAUTIs and CLABSIs, falls, hospital-acquired pressure injuries (HAPIs), sepsis, delirium and medical errors. A North Carolina team reduced length of stay 14%. A team in Alaska decreased HAPIs 56%. A Washington team reduced CAUTIs 92%. A team located in California decreased patient falls 50% and decreased positive scores for delirium by more than 25%. Communication projects have improved team collaboration and patient satisfaction. See **Table 1** for additional team outcomes. Some have reported decreases in RN turnover and overtime.

The CSI Academy curriculum included content to help teams sustain their results. In a one-year post-programme evaluation,

more than half of the respondents reported sustaining project results. An additional 28% of respondents reported somewhat sustaining project results (Lacey et al. 2017). DCNs also report translating these to other units and initiating new projects.

Nurse participants report significant personal and professional growth, especially in their leadership skillset. Total fiscal impact for the whole programme is $84.2 million and a 660% median return on investment per project. Overall satisfaction with the programme is very high. A majority of the CSI nurses agreed that they learned new skills to influence change, gained new tools and now feel more empowered to lead change. In addition, a large majority agreed that patient outcomes, nurse engagement, healthy workplaces and unit culture were improved. Hospital leaders had similar responses. CSIs noted improvement in leadership competencies in over 50% of 21 indicators measured.

Chief nursing officers (CNOs) involved with CSI Academy noted professional growth, increased confidence, improved collaboration skills and better ability to influence other team members in CSI participant.17 Implications of this programme are conveyed with the following CNO quotes: "I've never heard nurses talk about 'fiscal impact' before. This MUST continue!" "… provided the nurses with a personal experience, positive excitement and increased nurses' roles in research/quality – actually changed outcomes!" "Staff nurses are the key to building systems of quality. This programme proves just that."

Project Name	Topic	Outcomes	ROI*
Taking the Burn Out of Nursing	Nurse burnout	Decreased perceived stress of nurses; 14% decrease in sick calls and late clock-outs	290%
Stop, Communicate and Listen	Communication with staff	Decreased falls 4%; decreased incidence of CAUTI 50%; decreased HAPI 33%; decreased falls 25%	421%
Staying Alive	Rapid response teams	Increased rapid response team calls 23%; decreased code blue calls 75%; increased patients remaining on unit after RRT 10%	215%
Brain Matters	Early stroke detection	Initiated a stroke code; reduced ICU length of stay for stroke through early stroke identification	502%
Urinary Tract Infection (UTI) Prevention with CAUTION	Preventing catheter-associated urinary tract infection (CAUTI) and symptomatic urinary tract infection (SUTI)	Decreased UTIs 49%	720%
Do Five, Save a Life	Medication administration	Improved transcription medication errors 85%	1,972%

Table 1. Sample of CSI Projects

*All Return on Investment (ROI) numbers are estimated and may not represent the true cost. The amount invested for each team includes hospital investment for the AACN CSI Academy programme cost divided by the number of teams, CSI nurses' and coaches' hours, food, incentives and staff time to attend education and work on the project. It doesn't include back-fill hours for staffing, point of contact time or other staff such as data analysis personnel.

This table represents a portion of completed projects. For more information about all CSI Academy projects, see the Innovation Database at www.aacn.org/csi.

Conclusion

We must continue to leverage the knowledge and power of of registered nurses (RNs). With improving quality and transparency, organisations will need to seek ways to engage and leverage the knowledge, power and leadership of the nursing workforce. As leaders seek to stabilise workforce fluctuations related to the pandemic, identifying specific strategies to address patient safety and medical error prevention will also positively impact the empowered DCNs and their team. AACN CSI Academy provides nurses with the skills needed to change practice through QI efforts impacting outcomes and the fiscal health of their organisation. The 10-year history of AACN CSI Academy has demonstrated that when DCNs are provided the leadership skills and tools, protected project time and organisational support, optimal patient outcomes and fiscal outcomes are the result. Optimising patient care also positively impacts nurses and the care team. Growing and supporting DCNs' innovation and leadership is a return on investment – a win-win for patients, nurses and organisations.

Conflict of Interest

None. ■

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The Role of a Mortality Review Committee in a Paediatric and Maternity Hospital

There is little information in the current literature on the organisation of mortality review committees in paediatric and maternity hospitals. This article aims to explain the objectives and function of the mortality review committee of our hospital, an articulated tool to improve the quality of patient care based on reviews of deaths in our centre.

Aitor López-González
Paediatric Resident
Mortality Review Committee
Hospital Sant Joan de Déu Barcelona
University of Barcelona
Barcelona, Spain

aitor.lopez@sjd.es

Irene Casas
Obstetrics and Gynecology Resident
Mortality Review Committee
Hospital Sant Joan de Déu Barcelona
University of Barcelona
Barcelona, Spain

irene.casas@sjd.es

Elisabeth Esteban
Intensive Care Unit
Head of the Paediatric and Neonatal Transport Unit
Chairperson of the Mortality Review Committee
Hospital Sant Joan de Déu Barcelona
University of Barcelona
Barcelona, Spain

elisabeth.esteban@sjd.es

Josep Maria Casanella
Mercè Jabalera
Miquel Pons
Gemma Durban
Silvia Planas
Míriam Illa
Moira Garraus
Laura Saura
Lucía Navarro
África Pertierra
Laura Monfort

Pedro Palazón
Elena Blanco
Verónica González
Freddy Prada
Carles Luaces
Susana Segura
Iolanda Jordan
Blanca Muñoz

Mortality Review Committee
Hospital Sant Joan de Déu Barcelona
University of Barcelona
Barcelona, Spain.

Paediatric and maternity hospitals report far fewer deaths each year than adult general hospitals. Nevertheless, each case of death in these hospitals should not be less deserving of being analysed by the mortality review committee (MRC). In this way, by analysing each case and seeking strategies for improvement, the quality of care for other patients who may find themselves or end up in a similar situation can be optimised.

In addition, the MRC is a multidisciplinary tool that allows the end-of-life situations of different specialties to be compared, thus also enabling mutual learning on how to deal with them in difficult periods of life such as childhood, adolescence or pregnancy.

Barcelona Children's Hospital SJD is a highly specialised university centre for the treatment of children and pregnant women. It is a private, non-profit institution that is dedicated to public service since its creation in 1867 and belongs to the Hospitaller Order of Saint John of God, which manages more than 300 healthcare centres in 50 countries around the world and serves the most vulnerable groups in hospitals, health centres and social services. More than 2,100 professionals work at the hospital and it counts with more than 500 volunteers, 314 beds, 161 consulting rooms and more than 50 hospitalisations and 335 emergencies per day according to the annual report of 2019. In our case, the MRC is regulated by the Spanish National Institute for Health.

Purpose of the Mortality Review Committee

Its objective is to contribute to the improvement of the quality of care by evaluating and analysing in-hospital mortality and channelling the improvement actions proposed as a result of this analysis. MRC brings together experts who guarantee that the actions take into account different points of view, experiences, knowledge and skills, and those are produced in a harmonious and synchronised way within the hospital.

We analyse clinical management, processes, teamwork and especially holistic aspects. The perinatal mortality and the death of a child is always a devastating process for the family. The MRC also reviews whether the families have received all the support they need and that our hospital can provide. It also monitors the impact of deaths on our staff to check the special needs of our teams. We perform an annual report of the activity in this committee and register the trends on mortality in our hospital, as well as other quality indicators related to mortality. Another purpose of this committee is to increase the performance of autopsies in our hospital.

The MRC Team

The MRC is a multidisciplinary committee articulated by a chairperson and a secretary. The chair is responsible for leading the meeting and coordinating the entire team. The secretary is

responsible for scheduling the meeting and setting the agenda, as well as taking the minutes during the meeting and updating all the information and data collected from the meetings.

The departments represented on the mortality committee should be all those that are primarily responsible for patients who have died or may die in the hospital (cardiology, neurology, chronic and palliative care, oncology, haematology, paediatric surgery, gynaecology and obstetrics, as well as emergency, paediatric hospitalisation, neonatal and paediatric intensive care). These departments are mostly represented by physicians, although some of them also have nursing representation. The presence of nurses has been promoted, due to their crucial role in patient care and giving support to their families. In addition, as our centre is a hospital where specialised healthcare training takes place, residents in training are also invited to participate. Another department represented on the committee is the anatomical pathology department whose vision complements and helps to understand the outcome of the cases analysed and provides further information regarding the cases with a post-mortem examination. The MRC is also a competence of the quality and medical directors, so they are also active members of this committee. Their commitment underlines the importance of this group.

In these meetings there is an atmosphere of trust, with kindness by all members. Detailed analysis is facilitated in a psychologically safe environment, which is essential for admitting incidents and finding changes and opportunities for improvement.

MRC Meetings - Periodicity and Duration

The mortality committee meets on a monthly basis, although exceptionally there may be two meetings in a month if there are many cases or other issues to discuss at the meeting. The usual duration of the meetings is between one to two hours.

Prior to the MRC, each department discusses relevant cases with the rest of its team. Infant, fetal and maternal death closure meetings are held periodically in the hospital departments participating in the MRC. Following these meetings, the department representative on the MRC makes a report that is reviewed and discussed at the monthly MRC meeting.

This methodology has two main advantages: first, it speeds up MRC meetings and makes them more efficient. Secondly, the analysis of each team is crucial for the MRC members. Most of the time, the representative brings the observed weaknesses and proposed improvement actions. These are critically analysed by the committee in a constructive model to provide the best experience for the teams and the best in excellence for the whole institution.

MRC Meetings – Points of Discussion

Throughout each meeting, different cases of death are presented and discussed, most of them in first review and some in second review, proposals for improvement are established, proposals from previous meetings are reviewed and other issues are discussed.

The London protocol root cause analysis is the mortality-review process used. This protocol identifies care delivery processes and any contributory factors. MRC members label each case as death expected or unexpected (if it was not foreseeable at the time of

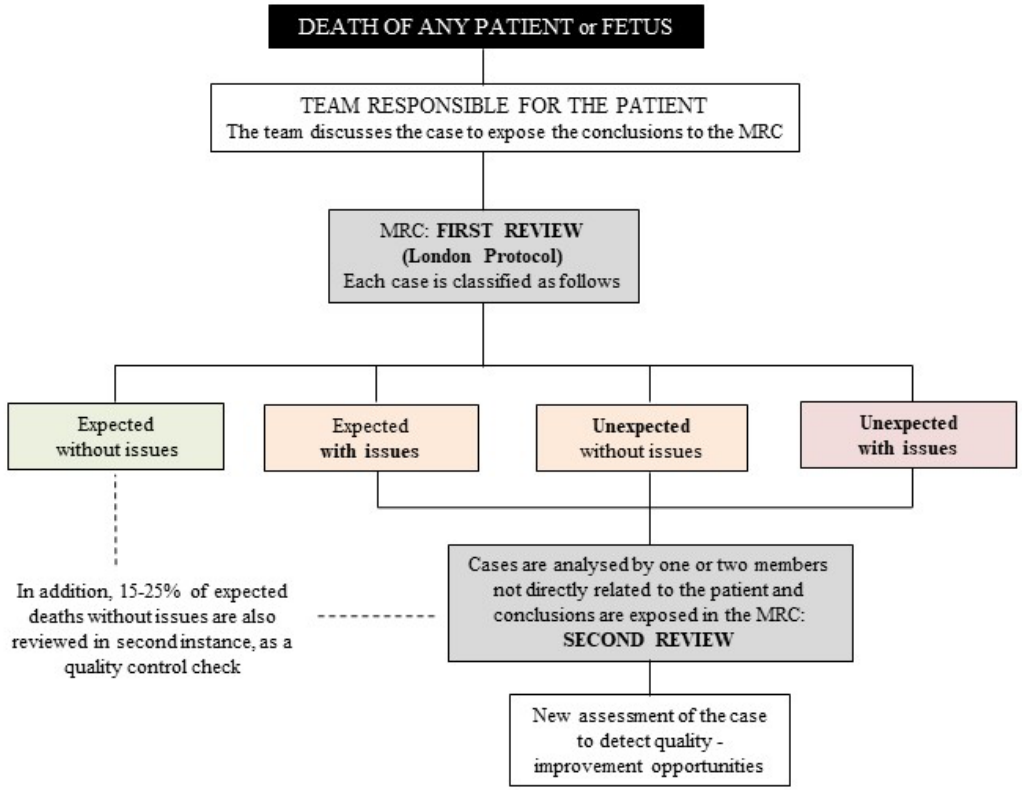

Figure 1. Mortality Review Process

admission or throughout the hospital stay) and without or with issues (with quality-improvement opportunity). This classification must be validated by all the members of the committee **(Figure 1)**.

As an example of our activity, in 2020 we analysed 83 exitus in the MRC, which represents 0.49% of 16737 admissions. The percentage of unexpected deaths was 9.63% (8/83) and deaths with issues, 6.02% (6/83). The intraoperative mortality was 0.007% (1/13881 surgeries). Autopsies were performed in 77.1% of deaths (64/83).

First reviews

In each meeting, a first review of all cases of death from the previous month are presented, as well as each one of the actions that were carried out by the medical team. Cases are exposed by the last team responsible for the patients. As we have mentioned before, these cases have been previously analysed by the primary teams.

The MRC members present at the meeting discuss and debate the management of the case and other related aspects. All members have the opportunity to give their opinion and the actions are validated by the whole committee. Each case is classified as follows: death to be expected or not, and death with or without issues. Improvement actions that could be applied to other similar patients are proposed. A person or team responsible for the actions is appointed.

Second reviews

Second case reviews are basically performed in two circumstances: in those cases where death was expected but issues were found and in those where death was not expected. Unlike the first review, which is presented to the mortality committee by the last team responsible for the patient, the second review is performed by one or two teams not directly related to the patient and who are members of the MRC. This member will again review the entire episode (and if necessary, the rest of the patient's medical record) to reissue a new assessment of the case and detect additional points of improvement from a more external point of view. It is advisable that the team that presented the case for the first time be present at the presentation of the second review, to discuss if any points are needed on the analysis made. These second reviews are very productive and beneficial for the teams and the MRC. In addition, 15-25% of expected deaths previously categorised as without issues are randomly reviewed and are also reviewed in a second instance, as a quality control tool. In 2020, we performed 16 second reviews out of 83 exitus (19.3%).

Follow up of improvement actions

Following every review (either first or second), improvements to the case may be proposed by any member of the MRC. Improvements suggested may be diagnostic and therapeutic, logistical or otherwise. The proposals made will be discussed in the committee and, if it is believed that they would have led to a better outcome of the case (not necessarily to avoid death), their implementation will be assessed in order to improve the quality of care offered by the centre to other patients who may be or may end up in similar circumstances. It is important that, at the organisational level, for each proposal made, it is decided which actions will be carried out, who will be responsible to implement them and when it will be reviewed again by the committee.

In fact, the status of improvement actions will also be discussed in future meetings. In 2020, 19 improvement actions were proposed, of which 13 (68.4%) were closed in 2020 and 6 (31.6%) were developed in 2021. Some of these improvement actions were: complete revision of the necrotising enterocolitis protocol, prevention of abdominal compartment syndrome in patients with congenital diaphragmatic hernia, revision of obstetrics protocols (maternal syphilis, chorioamnionitis), sepsis detection protocol and specific course for all hospital staff, creation of a team responsible for accompanying families after a death, among others.

Other topics

In addition to presenting case reviews and discussing improvement actions, every MRC meeting should have an open space at the end to discuss other topics that may be of interest to the committee. Examples of this could be literature reviews on a relevant topic related to hospital mortality, presentation of improvement projects presented in other centres to assess their feasibility on our own, as well as any other topic that a member of the committee believes may be of interest. In addition, this space can be used to discuss issues that cut across the centre's ethics and mortality committees (e.g. organ donation in paediatrics).

Last but not least positive actions detected during the case review (as well as processes, or management) are also assessed. It is based on Hollnagel's safety model (Hollnagel 2014). According to Hollnagel, the preoccupation with the traditional primary focus on error and risks (Safety 1) often leads to undervaluing an equally important safety force, namely inherent human resilience and preventive measures (Safety 2), by understanding the things that go right in everyday work. Fostering an appreciation of Safety 1 and 2 is the key to creating the greatest impact on quality, efficiency and patient safety.

Future Expectations

It is true that there is more and more knowledge about how to deal with end-of-life situations and less and less social taboo about death. Even so, deaths in paediatrics and obstetrics, both because of their infrequency and, in some cases, their unexpectedness, are still an issue that needs further work.

On the other hand, the development and optimisation of new diagnostic and therapeutic techniques in all specialties leads to the appearance of new clinical scenarios on a permanent basis, which means that the teams in charge of these patients must be aware of and actively debate the limitation/adequacy of the therapeutic effort and the decisions regarding the end of life of the patients for whom they are responsible. The subsequent review of deaths, especially in these new scenarios, allows a critical spirit to be maintained and to analyse what has been done correctly and what can be improved for similar situations.

Moreover, certain ethical debates, such as euthanasia or abortion, both regulated nowadays in our country, open the door to new scenarios that will surely be the subject of analysis by the

hospital's ethics committee and, probably in some cases, also by the MRC. In this line of ethical debates, asystolic organ donation in paediatrics will also be an issue to be addressed in the coming years. In addition, new scenarios such as the possibility of extubation at home in case of end-of-life situations in terminally ill patients should be considered in our committee.

Another future challenge for the mortality committee is to analyse and try to establish lines of improvement in the face of the exponential increase in cases of suicide and suicide attempts among the paediatric and juvenile population, especially following the start of the pandemic in March 2020.

Conclusions

The perinatal and paediatric mortality committee is a relatively simple tool to apply and carry out, allowing improvements to be implemented both at department level (through the review that each team carries out of its cases before presenting them to the committee) and at hospital level (once they are presented to the MRC). Beyond the cases presented, the relevance of the mortality committee lies above all in the strategies for improvement that are put forward at the meetings. Moreover, being a multidisciplinary committee allows for mutual learning between the different departments of the hospital.

> **"the mortality committee is a necessary entity as a quality strategy for the hospital"**

Due to the continuous progress inherent in science, as well as constant social changes, we will inevitably encounter new situations every day that will make us rethink what we have learnt so far. In this constant change of paradigms, the mortality committee is a necessary entity as a quality strategy for the hospital, due to its constant self-analysis and search for improvement in the quality of care for our patients.

Conflict of Interest

None. ■

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Mariana Joya-Ramírez
Facultad de Medicina
Benemérita Universidad Autónoma de Puebla
Puebla, México

marianajoyar17@gmail.com

Hassler Stefan Macías-Sánchez
Departamento de Ciencias de la Salud
Universidad de las Américas Puebla
Puebla, México

hassler.macias.md@gmail.com
@mac_hass2

Jorge Alberto Guevara-Díaz
Facultad de Medicina
Universidad Autónoma de Sinaloa
Sinaloa, México

jorgeguevara.med@gmail.com
@jorgeguevara092

Héctor David Meza-Comparán
Dirección de Investigación
Instituto Nacional de Geriatría
Mexico City, Mexico

hmezacomparan@gmail.com
@HectorMezaMD

Learning from Medical Errors

Healthcare professionals/trainees are often unprepared to experience and learn from errors due to structural characteristics of our systems and training programmes. Restructuration is needed to allow learning from errors.

Introduction

Medical error is considered one of the ten leading causes of death and disability in the world and as many as 4 in 10 patients are harmed globally (World Health Organization 2019). Mistakes not only impact patient safety, but also pose an emotional burden for medical staff (Fatima et al. 2021) since many of them experience emotions like anger, guilt, and remorse after medical errors occur (Christensen et al. 1992), with the risk of developing long-lasting conditions such as depression, burnout syndrome, impaired memory, and lack of concentration (Robertson and Long 2018), all of which leads to the notion of the "second victim" (Wu 2000). For these reasons, we should not only aim to prevent errors, but also seek to help healthcare professionals be prepared for their occurrence.

Becoming aware and speaking up about errors in clinical practice is an important part of the learning process of medical students (Chen et al. 2021). In fact, trainees may learn more from the errors they have personally experienced (Ryder et al. 2019). However, medical students are naturally prone to concealing their mistakes, instead of taking advantage of these personal experiences that may provide a fertile ground to explore their emotional responses to medical error and learn from them (Ryder et al. 2019; Lo et al. 2018).

Here, we will review the challenges that trainees experience when facing medical errors, and ways to integrate learning from medical errors with preparedness for them in medical training programmes.

Defining Medical Errors

Medical errors refer to preventable adverse events of medical care, even if not evident or harmful to the patient (Hofer et al. 2000). They can also be defined as an act of omission or commission that contributes or may contribute to an unintended consequence (Rodziewicz et al. 2022). Errors of omission arise because of actions not taking place. Examples of this include failure to prevent pressure ulcers or patient falls. On the other hand, errors of commission arise when a wrong action takes place. For instance, administering a blood product to the wrong patient or performing a wrong-site surgery. Most medical errors are not due to a single physician or group of physicians; instead, they are due to systems that foster error-prone situations (Rodziewicz et al. 2022).

Factors related to medical errors include physician inexperience, fast-paced environments (such as emergency departments, intensive care units, operating rooms), patients in extremes of age, novel procedures, prolonged in-hospital stay, low-resource settings, inadequate doctor-patient relationship, depression, burnout, among others (Rodziewicz et al. 2022; Lifshitz 2004).

As a response to the rise of patient harm and with the evolving complexity of healthcare systems, the discipline of Patient Safety emerged, aiming to prevent risks and errors arising during the provision of healthcare. It is defined as "the avoidance, prevention and amelioration of adverse outcomes or injuries stemming from the process of healthcare" (Vincent 2010).

What Impedes Us From Learning From Errors?

Error is inevitable as it is a fundamental part of the human condition. Nonetheless, there is a culture of infallibility in healthcare that punishes those involved in errors. When failure occurs, consequences may be hurtful or even fatal towards patients, but

Ashuin Kammar-García
Dirección de Investigación
Instituto Nacional de Geriatría
Mexico City, Mexico

kammar_nutrition@hotmail.com
@KammarAshuin

Javier Mancilla-Galindo
Unidad de Investigación UNAM-INC
Instituto Nacional de Cardiología Ignacio Chávez
Mexico City, México

javimangal@gmail.com
@Javimangal

can also potentially result in consequences for the careers of trainees and healthcare professionals. Because of this, it is implicitly discouraged to admit error, and physicians and students feel pressured to cover up rather than acknowledging their errors, causing a self-imposed silence in fear of blame and punishment. This phenomenon makes the connection between error and learning in medicine more difficult than in other disciplines, as it does not allow feedback.

It is imperative to be conscious of the great responsibility that comes with working with human lives, but rather than being afraid of making mistakes, we should be able to draw lessons from our errors enabling us to avoid their repetition and to build significant knowledge from them.

Most medical training programmes are well designed to provide trainees with the necessary knowledge to prevent errors by knowing what to do in certain circumstances (i.e., basic and advanced life support training). But patient and healthcare scenarios are so diverse that it is impossible to prevent all mistakes. Thus, emotional preparedness becomes even more imperative for trainees (Kiesewetter et al. 2018).

According to Lee et al. (2018) many medical students had difficulty during their clinical rotations to analyse and reflect on the medical errors they witnessed. Therefore, it is necessary to integrate a teaching model that focuses on the positive aspects of medical errors as learning opportunities. Education on patient safety and medical mistakes is also a strategy to prevent errors that needs to be implemented by medical schools (Gohal 2021).

Models of teaching through medical errors have shown that digital case studies are innovative ways of introducing key patient safety concepts and experiential practice of interprofessional communication in medical students (McCoy et al. 2020). The incorporation of simulation in medical education helps the student learn about mistakes that could be prevented under certain scenarios to develop confidence (Suleiman et al. 2021). Under these scenarios, students can experience and learn from medical errors in a controlled way.

How to Use Medical Errors as Opportunities to Learn

There are intrinsic and extrinsic factors involved in the process of using errors for educational purposes, the former being factors specific to the medical student's behaviour and the latter being part of the system and environment in which they develop. Bridging both aspects is important in order to build an interrelated system that favours learning and competency.

As part of the intrinsic factors, Shepherd et al. (2019) reported that, to promote learning in the circumstances of medical error, a change in the way medical trainees see failure is needed. Thus, it is necessary to normalise error as part of the learning process as well as having peer support and mentorship with a blame-free focus. The emotional response that accompanies medical error –such as guilt, shame, and grief– can enhance memory and bring desirable outcomes to the learning process as a catalyst and motivating force to take corrective actions.

Another crucial part of using error for learning that connects intrinsic with extrinsic factors is requesting help when needed, since supervision is a pillar in learning to be competent and autonomous in clinical practise. Kroll et al. (2008) mention that if medical students and residents are to gain experience and deliver good patient care, current systems of support and supervision must change. The study strongly suggests that clinical supervisors are key in the learning process and expectations should be clarified in three ways. Firstly, trainees must be explicit about when and whom to ask for help. Secondly, supportive, and constructive feedback on all decisions –good, bad and borderline– must accompany an omnipresent reassurance, since such discussions may lead to detection of near-misses – defined as potential adverse events that could have caused harm but did not, either by chance or because someone or something intervened (Rodziewicz et al. 2022) – and errors, building motivation to learn from error and attenuating stress. Thirdly, supervisors must ensure that trainees have an appropriate level of confidence and accept an appropriate level of responsibility for errors (Kroll et al. 2008).

Complementarily, a retrospective analysis of workshops addressing patient safety and supervision concluded that improved supervision and communication within the medical hierarchy has the power not only to create more productive learning environments but also to improve patient safety by addressing behaviours that would otherwise remain undetected or uncorrected (Ross et al. 2011).

Debriefing is a major tool that takes into consideration both intrinsic and extrinsic factors involved in learning, as well as the existing problems, encompassing solutions to achieve a meaningful learning experience. According to Cho (2015), debriefing is a conversational session that revolves around sharing and examining information after a specific event has taken place. It may follow a simulated or actual experience and provides a forum for the learners to reflect on the experience and learn from their mistakes.

Since medical learning is based on educational hierarchies in a closely related system, a chain effect can be achieved if everyone is trained in debriefing, which can occur in a simulation environment, but also in actual professional clinical practice. This could help improve confidence and experience in medical trainees and also develop assertive and open communication in a safe space,

allowing the evaluation of their performance, while also giving feedback on errors in a timely manner in order to learn from them. Helpful strategies to learn from medical errors are shown in **Figure 1**.

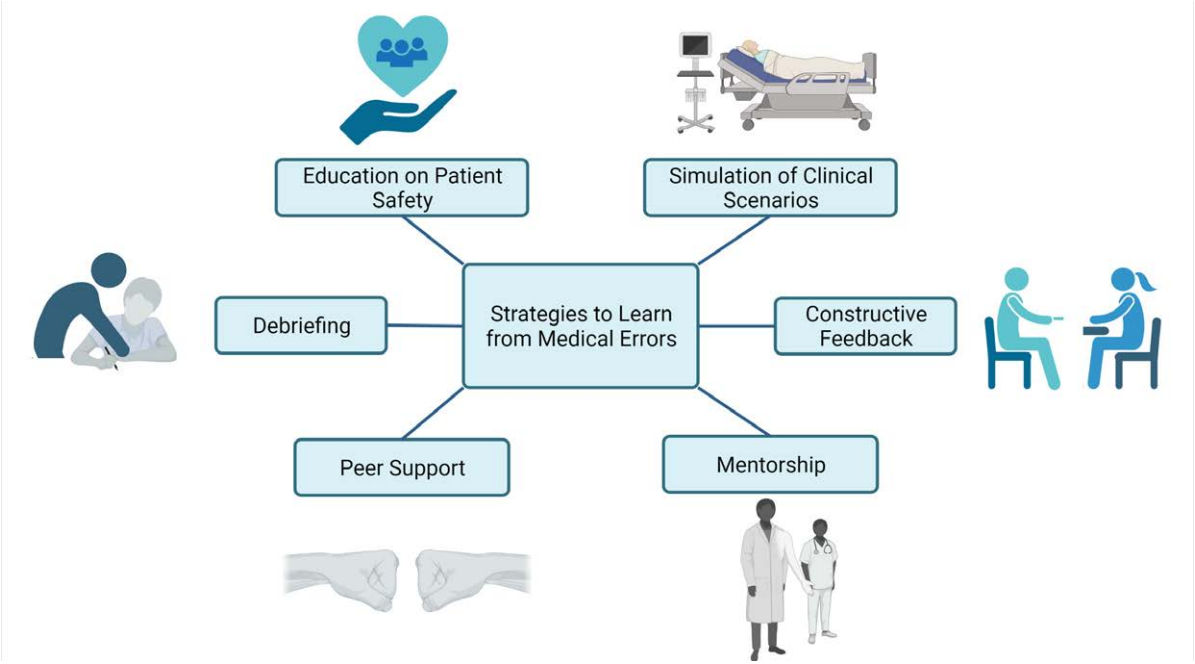

Figure 1. Strategies to learn from medical errors. Created with BioRender.com

Conclusions

A key step into the solution of medical errors is the promotion of a societal and institutional culture that accurately identifies safety challenges while implementing feasible action plans through education, training, and teamwork rather than a culture of blame, fear, and punishment, albeit preserving individual accountability. The entire healthcare systems must be constantly revised to make sure improvements are directed towards making a safer environment for both patients and physicians. All members of the healthcare team must ensure effective interprofessional communication, recognise and report a medical error when first noticed and provide timely support to their peers after an adverse event occurs.

Conflict of Interest

None. ■

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AGENDA

MARCH

1
ICU Management & Practice DigiConf Medical Error, Harm and Patient Safety
Virtual Event
https://iii.hm/1eh6

22-25
41st ISICEM
Brussels, Belgium
https://iii.hm/1eei

24-25
8th International Conference on Surgery & Anesthesia
London, UK
https://iii.hm/1eej

APRIL

18-21
51st Critical Care Congress SCCM 2022
Virtual event
https://iii.hm/1egu

23-26
32nd ECCMID
Lisbon, Portugal
https://iii.hm/1egv

27-29
ANZICS/ACCCN Annual Scientific Meeting 2022
Sydney, Australia
https://iii.hm/1egw

27-30
12th Congress of the European Pain Federation (EFIC 2022)
Dublin, Ireland
https://iii.hm/1egx

28-29
18th Annual Critical Care Symposium
Manchester, UK
https://iii.hm/1egy

28-30
22nd Annual NATA Symposium
Virtual event
https://iii.hm/1egz

MAY

4-6
10th EuroELSO 2022
London, UK
https://iii.hm/1eh1

4-6
33° SMART Meeting
Milan, Italy
https://iii.hm/1ehi

12-14
ESICM LIVES 40
Madrid, Spain
https://iii.hm/1eh2

13-15
Emirates Critical Care Conference
Dubai, UAE
https://iii.hm/1eh3

13-18
ATS 2022 Respiratory Innovation Summit
San Francisco, USA
https://iii.hm/1eh4

JUNE

1-3
ERAS 2022 – World Congress
Madrid, Spain
https://iii.hm/1eh0

4-6
Euroanaesthesia 2022
Milan, Italy
https://iii.hm/1eh5

For a full listing of events visit https://iii.hm/icuevents2022

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