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PICU-acquired complications: the new marker of the quality of care

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This article describes the rise in PICU-acquired morbidities and its impact on patient outcomes. It discusses early rehabilitation strategies to improve patient outcomes in PICU.

Introduction

Critical care has traditionally been focused on early recognition of life-threatening conditions, resuscitation, and stabilisation of organ dysfunction, and ultimately improving mortality. Our ability to deliver critical care and advanced life support has continued to improve over the last two decades, and as a result, mortality rates in children admitted to Paediatric Intensive Care Units (PICUs) have fallen significantly to an all-time low of 1-3% in developed nations (Burns et al. 2014; Hartmann et al. 2017; Namachivayam et al. 2010). Increased survival amongst critically ill children has resulted in the following consequences: Firstly, a population shift. Patients admitted to PICUs today are sicker and more complex. Critically ill children with pre-existing chronic co-morbidities have risen significantly; these patients now constitute 53-68% of the PICU population (Choong et al. 2018; Pinto et al. 2017). This group of patients has a significant impact on PICU practice and resources. They require the majority of our invasive therapies; they occupy the longest duration of stay, and they consume 81% of costs within the PICU (Briassoulis et al. 2004; Rennick and Childerhose 2015). Furthermore, they are our future patients; 35% of these children are readmitted to the hospital within 6 months following PICU discharge (Choong et al. 2018). The second consequence of improved survival amongst critically ill children is a significant rise in PICU-acquired complications (PACs) amongst survivors (Pollack et al. 2014). The incidence of PACs has risen dramatically, and now

far exceeds mortality. PACs are undesirable and unintended sequelae, distinct from the admission diagnosis, and acquired during their course of a child's PICU stay. Specifically, these include but are not restricted to iatrogenic withdrawal, delirium, and PICU-acquired weakness.

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The rise of PICU-acquired complications

The traditional practice in many PICUs is to sedate, restrain and immobilise critically ill children as they are often considered "too sick to move" (Choong et al. 2013). Subsequently, the majority of critically ill children are excessively sedated, and prolonged bed rest is a common practice in PICUs (Choong et al. 2013; Choong et al. 2014; Garcia Guerra et al. 2016). This paradigm, along with a lack of clinician awareness of harmful sequelae (Long and Williams 2016), has led to an increase in the following specific PACs in the last 10 years: iatrogenic withdrawal syndrome has risen from 17 to 57% (Anand et al. 2010; LaRosa and Aponte-Patel 2019), delirium has

increased from 10% to 25% overall and affects as many as 53% of mechanically ventilated children (Traube et al. 2017; Creten et al. 2011). PICU-acquired weakness, which less than a decade ago affected only 2%, now affects as many as 23% children (Table 1) (Choong et al. 2018; Kukreti et al. 2014). These morbidities are inter-related. Sedation depresses respiratory effort and prolongs mechanical ventilation; it hinders mobility and increases the risk of delirium and iatrogenic drug withdrawal (Silver et al. 2015; Ista et al. 2007). Immobility during critical illness causes neuromuscular atrophy and weakness (Koo et al. 2011), it exacerbates pain and agitation, further perpetuating the cycle of sedative administration. Immobility is also an independent risk factor for delirium (Vet et al. 2013; Kudchadkar et al. 2014). Sleep is commonly disrupted in critically ill patients, due to numerous factors such as a disruptive environment, invasive interventions, interruptions for nursing care, pain related to the underlying illness and pharmacological interventions (Kudchadkar et al. 2014). Sleep disruption results in delirium and insomnia, in addition to impaired immunity, catabolism, and respiratory compromise. Over-sedation, delirium, and weakness are therefore not distinct critical illness complications (Figure 1). Their pathogeneses are interrelated, and they lead to common adverse short and long-term outcomes (Vasilevskis et al. 2010). PACs are common; 61% of critically ill children develop one or more PACs (Choong et al. 2018). PACs are important to clinicians as well as patients; they are strongly associated

with prolonged mechanical ventilation, longer hospitalisation, and higher mortality (Kukreti et al. 2014; Ista et al. 2007; Traube et al. 2017). The development of one or more of these PACs is associated with an increased risk of poor functional recovery, poor quality of life, persistent neurocognitive and psychological sequelae, and increased parental stress following PICU discharge (Choong et al. 2018). Collectively these constitute the post-intensive care syndrome which we now understand affects a significant proportion of paediatric survivors and their families, as it does critically ill adults (Watson et al. 2018).

Safety priorities and knowledge gaps

Despite its increasing incidence, PACs continue to be under-recognised amongst PICU clinicians. Sedation is often prioritised over awakening and mobilisation, as key safety concerns are most commonly focused on preventing unplanned extubation (da Silva et al. 2008). Clinicians are comfortable with sedating patients, but are often uncomfortable with mobilisation, and allowing children to awaken (Long and Williams 2016; Treble-Barna et al. 2019). Clinicians therefore often have conflicting attitudes towards sedation – we understand the potential side effects, yet we express the desire for more sedation for our patients (Flaigle et al. 2016). Further challenges faced by PICU clinicians is that the majority of intubated children are infants and toddlers or because of developmental disabilities, are non-verbal. Movement and wakefulness in these children are therefore often interpreted as agitation and the need to escalate sedation. Benzodiazepines and opioids are subsequently administered to facilitate sleep, but to the contrary, these medications decrease restorative sleep and increase arousal frequency, leading to further agitation and deterioration in sleep quality (Kudchadkar et al. 2014). Many PICU physicians admit not recognising nor understanding how to assess for delirium in children (Long and Williams 2016). There is a lack of awareness that critically ill children are at significant risk of delirium, and that sleep disruption is extremely common (Garcia Guerra et al. 2016; Kudchadkar et al. 2014). Subsequently, there is a paucity of routine monitoring for delirium and non-pharmacological sleep

Table 1: PICU-acquired complications

PICU-acquired complications	Rate
Increasing incidence	
Iatrogenic Withdrawal ⁴	57%
Delirium ¹⁵	25%
PICU-acquired weakness ⁴	23%
Decreasing incidence	
Unplanned extubation ³⁴	0.5/100 ventilator days
Central line associated blood stream infection ^{52,53}	0.7-1.0/1000 catheter days
Pressure injury ⁵⁴	3.7/1000 patient days

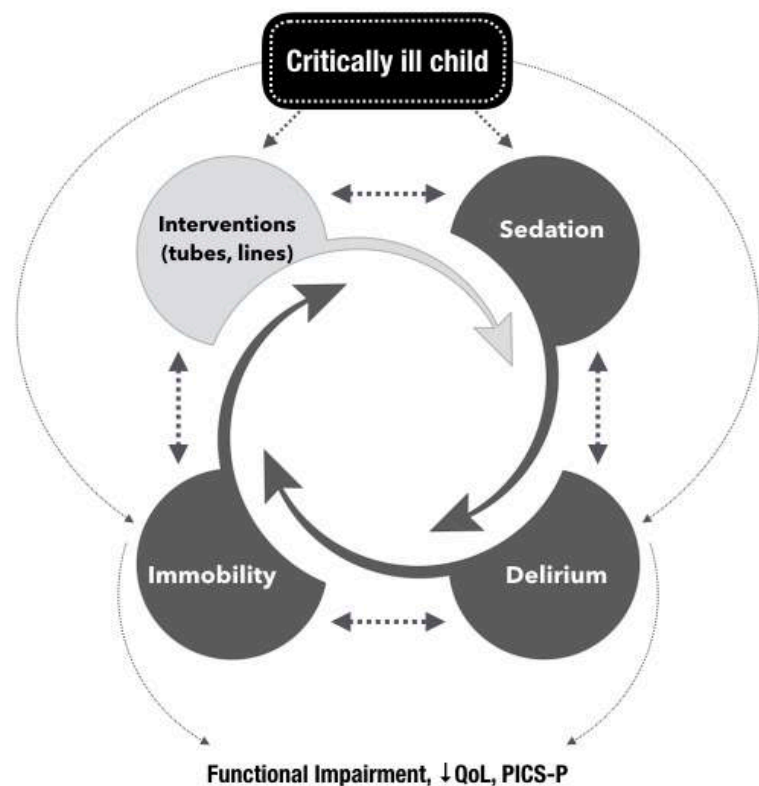


Figure 1. Common pathogenesis and sequelae of PICU-acquired complications. Figure modified with permission from Vasilevskis et al. (2010) Chest.

promotion in PICUs worldwide (Kudchadkar et al. 2014).

In summary, the rise in PICU-acquired complications are not only due to increasing complexity and co-morbidities amongst the critically ill paediatric population, but in

large part attributable to a traditional practice paradigm of excessive sedation, prolonged immobility, knowledge gaps with respect to the risk of our current practice and subsequently, a lack of standardised strategies for the monitoring of and prevention of these sequelae.

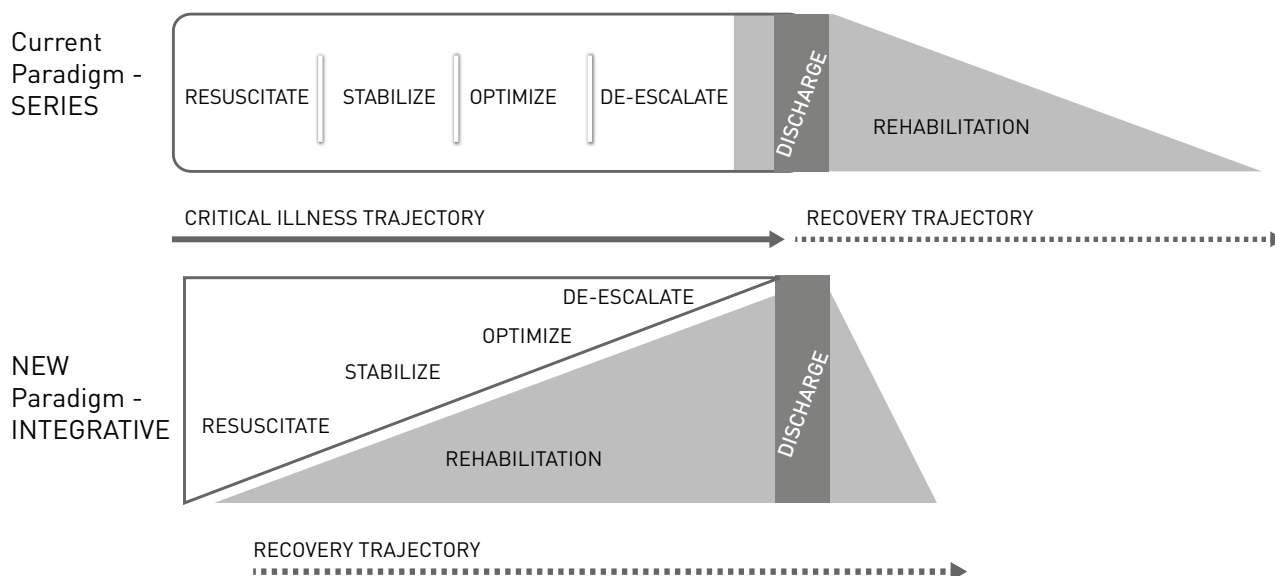


Figure 2. Paradigm shift, from a “series” to an “integrative” model, where rehabilitation is considered early, rather than the end of the critical illness trajectory.

Harm reduction and quality improvement

As the majority of critically ill children survive, mortality is no longer the most appropriate quality indicator of our care (Goodacre et al. 2015). Quality of life and function are now recognised as more meaningful and prioritised outcomes for patients and families (Merritt et al. 2018). PACs are common and harmful, but preventable, and therefore represent an opportunity for patient-centred, quality improvement in the PICU (Choong et al. 2018). As PACs impact long-term patient outcomes, reducing PACs may therefore not only improve PICU outcomes, but optimise functional recovery post-PICU discharge.

As over-sedation, withdrawal, delirium, and immobility are inter-related, single-pronged, independent interventions may not be the most effective approach to improve a common end-point of functional recovery (Craig et al. 2008). This may in part explain the lack of efficacy in previous studies targeted only at sedation or early mobilisation in isolation (Vet et al. 2016; Curley et al. 2015; Morris et al. 2016). Rather than providing different solutions to the same problem, addressing PACs collectively through a bundle of complementary quality improvement interventions enhances uptake and promotes multi-disciplinary

team collaboration (Dixon-Woods et al. 2012). Promoting early rehabilitation as harm reduction emphasises the importance of reducing ICU-acquired morbidities in optimising functional outcome and quality of life in critically ill patients. Implementing ICU-based rehabilitation through an “ABCDEF”

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Bundle is currently a topic of much research in critical care, and has been demonstrated in adults to significantly improve symptom-related outcomes such as the duration of mechanical ventilation, coma and delirium, as well as improved system and patient-related outcomes such as survival, hospital discharge and ICU readmission rates (Pun et al. 2018). Furthermore, there appears to be a dose-response relationship between higher

proportional bundle performance and improvements in these outcomes. With respect to the evidence for PICU-based rehabilitation the current evidence suggests that less is more: less sedatives, less benzodiazepines, and less immobilisation may reduce the length of hospital stay, reduce the risk of delirium, and improve adaptive functional outcomes (Fink et al. 2019; Mody et al. 2018; Simone et al. 2017; Penk et al. 2018). Minimum, effective sedation and analgesia has been shown to be safe, enables spontaneous breathing, improves sleep, reduces withdrawal and facilitates earlier mobilisation (Kudchadkar et al. 2014; Curley et al. 2015). Early mobility-based rehabilitation is feasible and safe in critically ill children (Choong et al. 2017; Cuello-Garcia et al. 2018). Implementing PICU-based early rehabilitation has been shown in preliminary studies to improve the time to and duration of mobilisation (Fink et al. 2019; Choong et al. 2017). Importantly, employing a rehabilitation bundle improves the unit culture through improved family engagement team collaboration and communication (Kawai et al. 2018; Costa et al. 2018). Whether an early rehabilitation bundle leads to improved short and longer-term patient important outcomes in critically ill children is a subject of ongoing research (Choong et al. ongoing research).

Early PICU-based rehabilitation, shifting the paradigm

While applying an ABCDEF bundle addresses PACs collectively, implementing PICU-based rehabilitation is complex and requires significant education, team collaboration, institutional buy-in, and continuous audit and feedback mechanisms to ensure sustainability (Balas et al. 2019). No longer is the critical care clinician's responsibility restricted to early recognition of clinical decompensation, resuscitation and improving survival, as the majority of children survive their critical illness. These patients are our future patients; we have a responsibility to our survivors to improve their survivorship, beginning within the PICU, to beyond the PICU. Creating a culture of practice begins with education and increasing awareness of PACs. Emerging paediatric-specific evidence highlighting the common incidence and source of key modifiable PACs is an important first step to raising awareness not just amongst clinicians, but to patients and families. Education should be targeted at paying equal attention and efforts to prevent common PACs, as we do to those that are infrequent (Table 1). Implementing ICU-based rehabilitation therefore requires a paradigm shift from considering the critical illness trajectory in series where rehabilitation is traditionally reserved to the "back end" of critical care, to an integrative model where rehabilitation is considered early in the critical illness trajectory as an important part of front-end care (Figure 2). An integrative model may provide us with the best opportunity to screen for and reduce morbidity prior to the onset of PACS, and

in so doing, optimise functional recovery. Understanding and improving ICU survivorship is a key focus of ongoing adult and paediatric critical care research, prompting novel interventional, quality improvement and implementation science research methods (Choong et al. ongoing research; Wiecek et al. 2016; Nydahl et al. 2018), as well as international collaboratives in identifying core patient and family-centred outcomes, and patient and family engagement in critical care research (Needham et al. 2017; Connolly and Hough 2017).

Conclusion

The success of paediatric critical care is evidenced by significant improvements in patient survival. However, these improvements are offset by the emergence of PICU-acquired morbidities both in the short term, as well as persistent long-term patient and family sequelae. Markers of success in critical care can therefore no longer be measured by survival, but improvements in longer-term survivorship post-PICU discharge. Improved understanding of populations shifts within the PICU, increasing awareness of PACs and the post-intensive care syndrome have offered us opportunities to highlight the importance of harm reduction, education and knowledge translation around survivorship following critical illness. A paradigm shift from early recognition and resuscitation, to early recognition and the introduction of ICU-based rehabilitation strategies, may offer us opportunities to reduce harm, improve the process of care, facilitate patient and family engagement team collaboration in clinical

care and critical care research, and most importantly, improve functional recovery and quality of life following critical illness.

Disclosures

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Key points

- Mortality rates in children admitted to Paediatric Intensive Care Units (PICUs) have fallen significantly to an all-time low of 1-3% in developed nations.
- Critically ill children with pre-existing chronic co-morbidities have risen significantly; these patients now constitute 53-68% of the PICU population.
- Sleep is commonly disrupted in critically ill patients, due to numerous factors such as a disruptive environment, invasive interventions, interruptions for nursing care, pain related to the underlying illness and pharmacological interventions.
- Despite its increasing incidence, PACs continue to be under-recognised amongst PICU clinicians.
- The rise in PICU-acquired complications are not only due to increasing complexity and co-morbidities amongst the critically ill paediatric population, but in large part attributable to a traditional practice paradigm of excessive sedation, prolonged immobility, knowledge gaps with respect to the risk of our current practice and subsequently, a lack of standardised strategies for the monitoring of and prevention of these sequelae.

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