

## In-situ emergency pediatric surgery in the intensive care unit

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### Abstract

**Background** The role of surgery in the intensive care unit (ICU) remains unclear. Although previous studies have not shown any increase in morbidity when operating on patients in the ICU for surgical procedures; there remains a reluctance to operate on sick patients in the ICU.

**Aim** We did a retrospective study of critically ill children and neonates who underwent in-situ surgery (ISS) to further evaluate its safety and potential. Surgery was aided with the use of operative loupes and high-intensity headlight.

**Methods** The medical records of all patients who had undergone surgical procedures in the pediatric ICU over an 11-year period from January 1998 till December 2008 were retrospectively reviewed. We reviewed our experience looking specifically at wound infection rates along with other morbidities in 543 patients.

**Results** Our morbidities were comparable with that of operations performed in the operating theater, with low wound infection rates (1 %) for all surgeries undertaken in the pediatric ICU.

**Conclusion** ISS avoids the risks of transfer to the operative theater and the potential delays in theater access. Our

results suggest that ISS in a tertiary-level pediatric surgical hospital is safe and does not impact adversely on clinical outcome.

**Keywords** ICU · In-situ surgery · Neonatal

### Introduction

Ligation of patent ductus arteriosus (PDA) in symptomatic unstable neonates within the ICU is well described, with results comparable to surgery performed in the operating room (OR) [1–3]. However, performance of other surgical procedure in the ICU is less well known. Editorial comments by Taylor et al. [3] first suggested the feasibility of performing surgery other than PDA ligation in the ICU. Lally et al. [4] reported no increased morbidity with Broviac catheter insertion in the ICU compared to surgery in the OR, whereas Finer et al. [5] reported on 81 general surgical procedures performed in critically ill neonates in a designated area of the ICU and found morbidity comparable to that seen in the OR. Recent reports have confirmed these observations and safety in operating in the ICU [6, 7]. In-situ surgery (ISS) avoids the transfer of an unstable patient to and from the OR, a process that may destabilize the clinical status of an already stressed, critically ill patient. We report our experience with pediatric surgical patients operated upon in the ICU. Management and organization of ISS are described.

### Materials and methods

A retrospective analysis was undertaken for all patients who had surgical procedures performed in the pediatric

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ICU over an 11-year period from January 1998 till December 2008. Data were collected from hospital records in relation to type of procedures performed, underlying diagnosis, clinical stability of the patients and outcome. Operations were performed in the ICU in an open incubator under a radiant warmer (Ohio Neonatal Care centre: Ohmeda, Columbia, MD, USA) the height of which could be adjusted to suit the operator. There was no attempt to isolate a separate operating area in the ICU, unlike other reports [5, 8]. The theater staff brought all the necessary equipment, instruments and drapes to the ICU. Conventional ICU monitoring consisting of continuous pulse oximetry (N-180: Nellcor, Hayward, CA, USA), continuous blood pressure and heart rate monitoring (Sirecust 1281: Siemens, Danvers, MA, USA) was employed. Ventilator requirements were monitored and adjusted by an experienced anesthetist.

Intravenous anesthetic agents were used in all cases, as no scavenging system for inhalation anesthetics was available. An IV opioid (fentanyl or morphine) combined

with a non-depolarising muscle relaxant (pancuronium, atracurium or vecuronium) was used in 81 % of cases in this series: ketamine and pancuronium were employed in the remaining 19 %. A grounding pad of electro-cautery was placed under the gluteal area. The patient was placed on a warming pad and temperature monitored with a transcutaneous temperature probe (Sirecust 1281: Siemens, Danvers, MA, USA). Illumination was provided by a head-mounted xenon fiber-optic light source (Universal Series 1900: Luxtec Fibreoptics, Worcester, MA, USA). Gowning, skin preparation and draping were performed as in the OR. Magnification surgical loupes ( $\times 4.5$ : CLS Medical) facilitated surgical technique. Operative and postoperative management did not differ from standard practice.

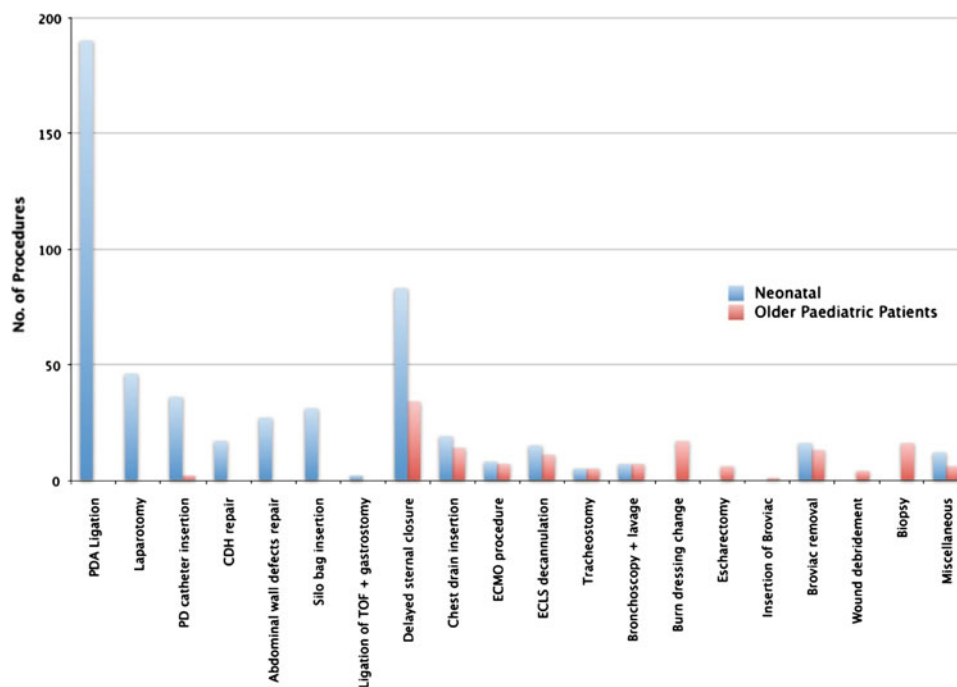
## Results

Over the 11-year study period, 657 general surgical procedures were performed on 543 patients comprising both neonates ( $n = 438$ ) and older paediatric patients ( $n = 105$ ). The neonates were all critically ill as illustrated in Table 1: a total of 491 procedures were performed in this group whereas 143 general surgical procedures were performed in infants and children (range 1 month–16 years) (Fig. 1). These were all critically ill, ventilated with preoperative inotrope support necessary in 63 cases (44 %). Cardiothoracic-related surgical procedures, such as PDA ligation or delayed sternal closure, represented 46.7 % (307 procedures) of the total number of surgical procedures performed in the ICU.

**Table 1** Neonatal preoperative stability and demographics

Parameters	Mean	Range
Birth weight (g)	1,125	510–3,750
Gestational age (weeks)	28.5	23–41
Preoperative weight (g)	1,550	780–3,400
Preoperative inotrope support	245 (56 %)	
Preoperative mechanical ventilation	438 (100 %)	

**Fig. 1** Different surgical procedures performed on pediatric ICU patients with the majority being cardiothoracic cases



The overall mortality was 3% ( $n = 16$ ). Eight of these patients (50 %) had NEC with the majority (75 %) of patients in the mortality group having septicemia-related deaths. Other factors contributing to death include bronchopulmonary dysplasia, intraventricular hemorrhage, respiratory distress syndrome, disseminated intravascular coagulopathy, and hypertension.

The mortality can be explained by the degree of prematurity and associated life-threatening illnesses in these unstable infants. There was no surgical procedure-related mortality. There were a few non-significant surgical procedure-related morbidity, but comparable to operations done in the OR. There were only seven (1 %) cases of wound infections treated with antibiotics. Three were associated with NEC surgery, a further three associated with delayed sternal closure and one associated with a muscle biopsy. Complications relating to operating within the ICU did not occur.

## Discussion

Operating on the critically ill neonatal and pediatric patient is traditionally performed in the OR. A major exception has been ligation of PDA in the unstable premature neonate in whom transfer to the OR can cause significant problems and morbidity. Our results clearly reflect this in which almost half (46.7 %) of the surgical procedures performed in the ICU were cardiothoracic-related surgeries. Most of the cardiothoracic-related procedures performed were PDA ligations (190 cases), where this procedure has been well documented to be safely done in the ICU setting [1–3]. Although previous reports have shown that Broviac catheter insertion and other surgical procedures may be safely performed in the pediatric/neonatal ICU, there remains a reluctance to operate on such patients in the ICU [3–7]. The morbidity between the cardiothoracic and non-cardiothoracic cases is similar, such as wound infections rates, with three documented cases in the cardiothoracic-related surgical procedures and four cases in the non-cardiothoracic cases.

Transfer of critically ill patients is time-consuming, utilizes considerable manpower and requires a suitable portable ventilator and extensive monitoring equipment. ISS avoids the potential for endotracheal tube or line disconnection, transfer hypothermia and the general decompensation that is not uncommon with transfer of the critically ill neonate or older pediatric patient [2, 3, 8]. In addition, disruption of a heavily utilized OR is avoided, as is the usual delay between booking and performing emergency surgery [5]. Although theater staffs are required for ISS, this is considerably less demanding than accommodating emergency cases in a busy OR. ISS further facilitates continuity

of care, allowing the same nursing, intensivist and anesthetic teams to care for the patients through all phases of their ICU stay.

Concerns remain, however, that ISS is associated with greater risks than conventional OR surgery. Notable is the concern that ISS is associated with a higher risk of infection. Several authors have demonstrated no increase in catheter associated or wound infection following ISS. Eggert et al. [9] and Taylor et al. [3] performed 79 and 52 PDA ligations as ISS, respectively, and recorded no wound infections. Lally et al. [4] reported no difference in catheter-associated sepsis with positive blood cultures when comparing Broviac catheter insertion in the OR and the ICU. There were only 7 (1 %) wound infections in our series. The emergence of multiple-antibiotic-resistant organisms, such as gentamycin-methicillin-resistant *Staphylococcus aureus* and vancomycin-resistant enterococci, has presented unique problems in the transfer of patients from the ICU to the OR. ISS avoids the risk of cross contamination and the subsequent cleaning process of the OR.

Although straightforward, ISS requires the constant back-up of a fully staffed and equipped pediatric OR to meet the significant and often unforeseen demands of surgery. Typically, a circulating nurse will make several excursions to the OR during an ISS procedure. Provision of a fully stocked, mobile supply cart may overcome this problem. Operating in the open section of the ICU does, however, because a certain disruption to the ICU while the operative area is screened off, and can limit parental access in the immediate operative area. Furthermore, operating on an older child on an ICU bed rather than a neonate in a narrow, open incubator can be uncomfortable for the surgeon and ultimately may be suitable for short procedure only.

## Conclusion

This is one of the largest retrospective studies related to the surgical care and intervention in critically ill neonates and pediatric patients who are too ill to transfer to the OR, and in our experience can undergo surgery in the ICU environment of a fully equipped hospital safely. We recommend that ISS within the ICU be performed in a tertiary referral pediatric surgical hospital, equipped with the necessary equipments and local expertise in surgical and nursing care within the ICU. No specific area within the ICU is necessary, and patients may undergo complex surgery where they lie. The potential disadvantages, which include infection, confined quarters with inadequate light, suction, cautery and departure from OR protocol, have not been borne out in practice. Meticulous attention to technique and sterility has resulted in no increased incidence of

wound infection. Magnification loupes greatly facilitate operative technique. Illumination can be provided by a portable fiber-optic headlamp. Scheduling emergency surgery in the ICU can be easier than interrupting a busy OR schedule. These large series support the safety and feasibility of ISS and further contends that outcome is not influenced by the site of surgery, but rather, is determined by severity of the co-morbid condition of the patient.

**Conflict of interest** None.

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