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ORIGINAL ARTICLE

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In-situ emergency paediatric surgery in the intensive care unit

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Abstract The role of surgery in the intensive care unit (ICU) remains unclear. Although previously shown not to increase morbidity for patent ductus arteriosus ligation, Broviac catheter insertion, and recently, general neonatal and paediatric surgery, there remains a reluctance to operate on sick patients in the ICU (in-situ surgery, ISS). A retrospective study of 25 critically ill children and neonates who underwent ISS was performed. Surgery was aided by operating loupes and a high-intensity headlight. ISS was not associated with any morbidity, and although a 36% mortality occurred in this small series, in no case was this due to ISS. ISS avoids the risks of transfer to the operating theatre and the potential delays in theatre access. Our results suggest that ISS in a tertiary-level paediatric surgical hospital is safe and does not impact adversely on clinical outcome.

Key words Intensive care unit · Surgery · Paediatric

Introduction

Ligation of a patent ductus arteriosus (PDA) in symptomatic, unstable neonates within the intensive care unit (ICU) is well-described, with results comparable to surgery performed in the operating room (OR) [5, 8]. Performance of other surgical procedures in the ICU is less well known. Editorial comments by Taylor et al. first suggested the feasibility of performing surgery other than PDA ligation in the ICU. Lally et al. [6] reported no increased morbidity with Broviac catheter insertion in the ICU compared to surgery in the OR. Finer et al. [3] reported on 81 general surgical procedures performed in critically ill neonates in a designated area of the ICU, and found a morbidity comparable to that seen in the OR. Recent reports have confirmed the safety of operating in the ICU [4, 7].

In-situ surgery (ISS) avoids transfer of an unstable patient to and from the OR, a process that may destabilise the clinical status of an already stressed, critically ill patient. We report our experience with critically ill paediatric surgical patients operated upon in the ICU. Management and organisation of ISS is described.

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Materials and methods

A retrospective analysis was undertaken of all patients who had surgical procedures performed in the paediatric ICU over a 30-month period, from January 1994 to June 1996. Data were collated from hospital records in relation to type of procedure performed, underlying diagnosis, clinical stability of the patient, and outcome.

Operations were performed in the ICU in an open incubator under a radiant warmer (Ohio Neonatal Care Centre; Ohmeda, Columbia, MD), 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 [1, 3]. The theatre 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), continuous blood pressure, and heart rate monitoring (Sirecust 1281; Siemens, Danvers, MA) was employed. Ventilator requirements were monitored and adjusted by an experienced anaesthetist.

Intravenous anaesthetic agents were used in all cases, as no scavenging system for inhalation anaesthetics 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 for electrocautery was placed under the buttocks. The patient was placed on a warming pad and temperature monitored with a transcutaneous temperature probe (Sirecust 1281; Siemens, Danvers, MA). Illumination was provided by a head-mounted xenon fibre-optic light source (Universal Series 1900; Luxtec Fiberoptics, Worcester, MA). Gowning, skin preparation, and draping was 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 30-month study period, 27 general surgical procedures were performed on 25 patients comprising both neonates ($n = 16$) and older paediatric patients ($n = 9$). The neonates were all critically ill as illustrated in Table 1; a total of 18 procedures was performed in this group (Table 2). Nine general surgical procedures (Table 3) were performed in 9 children over 1 year of age (range 1–12.3 years). These were all ventilated, critically ill patients, with preoperative inotrope support necessary in 4 cases (44%).

There was no surgical procedure-related morbidity and, significantly, there were no wound infections. The overall mortality was 36% ($n = 9$). Factors contributing to death are shown in Table 4. The high mortality can be explained by the degree of prematurity and assoiciated life-threatening illnesses in these unstable infants. There was no surgical procedure-related mortality. Complications relating to operating within the ICU did not occur.

Table 1 Neonatal preoperative stability

	Mean	Range
Birth weight (g)	1,915	560–3750
Gestational age (weeks)	32.25	24–41
Preoperative weight (g)	2,142	780–5,400
Preoperative inotrope support	8 (50%)	
Preoperative mechanical ventilation	16 (100%)	

Table 2 Neonatal procedures performed in ICU (*NEC* necrotising enterocolitis, *TOF* tracheo-oesophageal fistula, *GA* general anaesthesia)

Laparotomy/bowel surgery	$n = 5$
Ileostomy formation ($n = 1$)	
Resection small bowel ($n = 2$)	
Oversewing gastric perforation ($n = 1$)	
Adhesolysis ($n = 1$)	
Peritoneal drain insertion (perforated NEC) under GA	$n = 4$
Insertion of tissue expanders (conjoined twins)	$n = 2$
Ligation of TOF, gastrostomy	$n = 2$
Congenital diaphragmatic hernia repair (stablised)	$n = 2$
Bilateral inguinal herniotomy	$n = 1$
Miscellaneous	$n = 2$

Table 3 Procedures performed on older paediatric patients in ICU

Laparotomy	$n = 2$
Removal of lost peritoneal catheter guidewire	
Drainage of intra-abdominal collection	
Change of dressings in burn patients (mean burn area: 33%)	$n = 7$

Discussion

Surgery of the critically ill neonatal and paediatric patient is traditionally performed in the OR. A major exception has been ligation of a PDA in the unstable premature neonate in whom transfer to the OR can cause significant problems and morbidity. Although previous reports [3, 4, 6–8] have shown that Broviac catheter insertion and other surgical procedures may be safely performed in the paediatric/neonatal ICU, there remains a reluctance to operate on such patients in-situ in the ICU.

Transfer of critically ill patients is time-consuming, utilises 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 illl neonate or older paediatric patient [1, 5, 8]. In addition, disruption of a heavily utilised OR is avoided, as is the usual delay between booking and performing emergency surgery [3]. Although theatre staff 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 anaesthetic teams to care for the patients through all phases of their ICU stay.

Table 4 Factors contributing to mortality (*BPD* bronchopulmonary dysplasia, *IVH* intraventricular haemorrage, *RDS* respiratory distress syndrome, *DIC* disseminated intravascular coagulopathy, *NEC* necrotising enterocolitis)

Birth weight (g)	Indication for surgery	Surgical procedure	Causes of death	Days after surgery
750	NEC with perforation	Peritoneal drain insertion	Respiratory failure, BPD, IVH	23
985	NEC with perforation	Peritoneal drain insertion	RDS, septicaemia, IVH	4
850	NEC with perforation	Resection of necrotic bowel	RDS, septicaemia	1
1,060	NEC with perforation	Resection of necrotic bowel	RDS, septicaemia	1
3,280	Small-bowel obstruction	Laparotomy and adhesiolysis	Septicaemia, DIC	1
5,400	Thoraco-omphalopagus	Insertion of tissue expanders	Single cardiac complex, cardiac failure	10
3,750	Undiagnosed congenital syndrome	Liver, muscle, skin biopsies	BPD, septicaemia	0
4,060	Free intra-abdominal peritoneal catheter guidewire	Laparotomy and removal of guidewire	Renal failure, hepatic failure, cardiac failure	6

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 infections following ISS. Eggert et al. [2] and, Taylor et al. [8] performed 79 and 52 PDA ligations as ISS, respectively, and recorded no wound infections. Lally et al. [6] reported no difference in catheter-associated sepsis with positive blood cultures when comparing Broviac catheter insertion in the OR and the ICU. There were no wound infections in our series. The emergence of multiple-antibiotic-resistant organisms such as gentamicin-methicillin-resistant *Staphlococcus aureus* and vancomycin-resistant enterococci has presented unique problems in the transfer of protients 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 paediatric 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, cause 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 procedures only.

In our experience, critically ill neonates and paediatric patients who are too ill to transfer to the OR can undergo safe surgery in the ICU environment of a fully-equipped paediatric hospital. 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, and 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 fibreoptic headlamp. Scheduling emergency surgery in the ICU can be easier than interrupting a busy OR schedule. This small series supports the safety of ISS and further contends that outcome is not influenced by the site of surgery, but rather, is determined by the severity of the comorbid condition of the patient.

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