Use of neonatal intensive care unit as a safe place for neonatal surgery

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Abstract

***Aim*—To evaluate the advantages, disadvantages, and short term morbidity and mortality of major surgical interventions performed in the neonatal intensive care unit.**

***Methods*—A retrospective case review of 45 neonates was performed from April 1991 to September 1995. The characteristics of the patients were: gestational age 29 (SD 4) weeks (range 24 to 41 weeks); birthweight 1305 (870) g (range 540 to 4040 g); presurgical weight 1430 (895) g (range 550 to 4370 g); postconceptional age at surgery 31 (4) weeks (26 to 47 weeks). The indications for surgery were: ligation of patent ductus arteriosus (n=16); insertion of a subcutaneous ventricular catheter reservoir for hydrocephalus (n=14); repair of congenital diaphragmatic hernia (n=2); open lung biopsy (n=1); and laparotomies (because of necrotising enterocolitis, anorectal malformations, and intestinal obstructions) (n=12). The management of these neonates at laparotomy was: bowel resection with stomas (n=8) and stomas (n=4). No specially designed area was used to perform surgery.**

***Results*—Local or systemic infection associated with surgery was not seen and no perioperative mortality was related to the surgical procedure.**

***Conclusions*—The neonatal intensive care unit is suitable for major surgery during the neonatal period and no special area is needed to perform complication free surgery.**

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In the past decade, improvements in the treatment of neonates within the neonatal intensive care unit have resulted in increased survival, particularly in extremely low birthweight infants. Furthermore, the need for surgery—for example, patent ductus arteriosus, necrotising enterocolitis, and posthaemorrhagic hydrocephalus—on very small premature infants has also increased.

In most neonatal centres neonatal surgical interventions, with the exception of the operative closure of the patent ductus arteriosus,[1] are usually performed in the operating theatre, not in the unit. This means that transportation, extra manipulation, and a change of ventilator are all required, as well as interrupting the care of an unstable infant.[2] The reason for this policy is based on the major concern that a neonatal intensive care unit does not provide a clean operating area, and so predisposes to a higher risk of surgical and postoperative infection. However, since April 1991, all major neonatal surgery on critically ill infants has been performed in our neonatal intensive care unit, without moving the patients.

This report is an evaluation of the advantages, disadvantages, and short term morbidity and mortality of major surgical interventions performed in our unit over the past four years.

Methods

Data from 45 infants who underwent surgical interventions in the unit between April 1991 and September 1995 were collected retrospectively. Surgery was performed in the unit when the patients were clinically unstable, on mechanical ventilation, or weighed 2000 g or less. Surgical placement of central lines and extracorporeal membrane oxygenation cannulations and decannulations, which are routinely performed in the unit, were excluded from the assessment.

The unit has 13 intensive care beds, each one with an available area of 9 m^2.

Infants with an unstable thermoregulation were operated on inside their closed incubators; infants with stable control of body temperature were placed on an open incubator, but were not moved from their place.

Wall partitions isolated the operation site. The staff working in the unit wore cap and mask, but only the operating team wore surgical clothes. Regular activities in the unit were not suspended (radiography, ultrasonography, blood samples, etc.). Parents of other patients were allowed into the unit to visit their infants.

When the patient was not mechanically ventilated preoperatively, endotracheal intubation was performed by the paediatric resident or the neonatologist. Monitoring of the patient included: pulse oximetry; invasive or non-invasive blood pressure monitoring; electrocardiography; measurement of heart and respiratory rate and core temperature. Vascular access was assured before surgery. Infants were not premedicated, while intravenous anaesthetics in combination with non-depolarising muscle relaxants were used. Induction of anaesthesia was obtained using intravenous fentanyl 10 mcg/kg/bolus and paralysis was obtained using intravenous pancuronium or vecuronium 0.10 or 0.15 mg/kg/bolus. Titration of anaesthetics,[3 4] fluid, and blood replacement were indicated by the neonatologist and

Table 1 Mean (range) clinical characteristics of infants (n=45) undergoing surgery April 1991 - September 1995

Gestational age	29 weeks (24–41)
Birth weight	1305 g (540-4040)
Postconceptional age at surgery	31 weeks (26–47)
Weight at surgery	1430 g (550-4370)

Table 2 Types of operations performed between April 1991 and September 1995 (n=45)

Type of surgery	*Number (%) of patients*
Ligation of PDA	16 (35.6)
Subcutaneous ventricular shunt	14 (31.1)
Laparotomy	12 (26.7)
Repair CDH	2 (4.4)
Open lung biopsy	1 (2.2)

the anaesthetist. Prophylactic antibiotics were used during the insertion of the subcutaneous ventricular reservoirs, and intraoperatively only in case of a previously suspected or confirmed infection.

The unit nurses continued their normal care of the patient while the nurses of the main operating theatre attended the surgical procedure. Illumination was provided by portable fibre optic head lamps and procedure lamps. All infants remained ventilated after surgery and further care was provided by the unit team.

All data are presented as mean and standard deviation or ranges.

Results

The patient details are given in table 1; the types of surgery are described in table 2. Skin to skin operation time was between 30 to 90 minutes. The fraction of inspired oxygen (FIO_2) or ventilator settings were perioperatively adjusted to maintain arterial saturation between 86 to 96%, depending on the gestational age. Body temperature was maintained within the normal range for gestational age.

No local or systemic infection associated with the surgical procedure was present within the subsequent 72 hours after the procedure.

There were three perioperative deaths: the first was a premature infant born after 35 weeks of pregnancy, tranferred to our unit four days postnatally due to abdominal tenderness, shock, and signs of disseminated intravascular coagulation. The infant needed cardiopulmonary resuscitation before, during, and after laparotomy and died shortly after surgery. The laparotomy revealed a distal intestinal obstruction due to meconium ileus. Blood, ascites, and urine cultures showed growth of *Escherichia coli*.

The second death was an asphyxiated premature infant of 26 weeks gestational age with intractable hypotension and a major left to right shunt due to patent ductus arteriousus which required ligation at three days after birth. He died on day 4, developing an intraventricular haemorrhage after treatment had been discontinued because of an adverse prognosis.

The third death was an asphyxiated premature infant born after 29 weeks of pregnancy, weighing 650 g. His mother, a recipient of a kidney transplantation, had received prednisone, azathioprine, and cyclosporine. The patent ductus arteriousus was ligated one day after birth due to hypotension and oliguria. He remained in shock in spite of maximal treatment and died one day later after treatment had been stopped.

Discussion

Our results have shown that the neonatal intensive care unit is a safe place in which to perform surgical procedures, even on extremely sick and unstable infants, as no infection or other complications related to the surgical procedures occurred within the first 72 hours of the procedures.

The choice between the unit or the operating theatre as the location for surgery offers some interesting points for discussion. At present, the operating theatre is the preferred location to perform surgical procedures: surgeons and anaesthetists consider it their "natural environment" and it offers the required sterility.

The reluctance to operate on patients within the unit is based on the assumption of an increased risk of local or generalised infection. However, no published studies so far substantiate this assumption.

A primary disadvantage of surgery in the operating theatre is that having to transfer infants backwards and forwards increases the potential risk of hypothermia, disrupts vascular lines or chest tubes, and can accidentally dislodge endotracheal tubes. Other possible disadvantages include incompatibility between the monitoring equipment of the operating theatre and that of the unit, lack of "unconventional" respiratory support, such as high frequency oscillation in the main operating theatre or in the transport incubator, and delays due to lack of immediate availability of an operating theatre.

An essential advantage of performing surgery in the unit is the continuity of the care by the intensive care team in cooperation with the anaesthetist.

Whenever a decision to operate was made, our unit was immediately made available and the patients were ready for surgery when surgeon and anaesthetist arrived. Transfer and set up of the necessary equipment took place efficiently. By performing surgical procedures in the neonatal intensive care unit, optimal continuity of care before, during, and after surgery was provided. Neither transportation nor use of new equipment was required, and hypothermia and overhydration were avoided. The major concern of wound or systemic infection related to the surgical intervention was obviated.

The overall perioperative mortality of 6.7% was attributed to pre-existing conditions or to causes not directly related to the surgical procedure or the unit location.

The multidisciplinary medical team that managed the patients within the unit was, with the exception of the anaesthetic nurse, the same team that would have managed them in the operating theatre. The function of the anaesthetic nurse was transferred to a unit nurse, thus saving anaesthetic nursing time.[5]

The question of whether the neonatal intensive care unit is a better location than the operating theatre for performing major surgery cannot be answered by this study, in the absence of a random allocation of the infants to one or other location. However, we have confirmed that neonatal surgery can be performed in the neonatal intensive care unit.

There are no available data from randomised studies that compare the neonatal intensive care unit and the operating theatre for performing neonatal surgery. The only non-randomised, retrospective study which compared both locations was performed by Finer *et al.*[2] The authors performed surgery in a specially designated area of the unit. Furthermore, the patient characteristics and the various conditions requiring surgery within the operating theatre and the unit groups were not the same.

This study dispels the concern that the neonatal intensive care unit cannot be a clean operating area, and shows that it is possible to perform major surgical procedures on critically ill infants there without complications.

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Commentary

The suggestion that surgery can be performed in the neonatal intensive care unit may come as a shock to many neonatologists. But on closer inspection, the concept has considerable appeal. Transfer from the unit to the operating theatre within the same hospital will involve four major moves into and out of a transport incubator, and transfer between hospitals is even more hazardous. The risks of extubation, hypothermia and equipment and monitoring disconnection could all be reduced by performing surgery in the neonatal intensive care unit, and the need to discontinue vital treatment during transfer—for example, nitric oxide—could be avoided. Continuity of care by neonatal medical and nursing staff would be a great asset, not only to the patient, but also to the paediatric anaesthetist who may be unfamiliar with the patient's ventilatory and circulatory idiosyncrasies.

Balanced against this are the considerable challenges posed by performing surgery in such an environment. The authors of this paper are particularly concerned to show that there was no increase in the rate of infection as a result of surgery in the unit—something they have not actually been able to prove, given the small sample size and lack of control group—but this may not be the most important risk factor. Major neonatal surgery is always a considerable technical challenge. Vital factors include accessibility, lighting, the immediate availability of the surgical equipment required to cope with the unexpected, and an experienced theatre team. The prospect of undertaking a difficult intestinal anastomosis on a 900 g infant in an incubator (with the light reflecting off the surface), with restricted access and in a stooped position is bad enough, but if that infant then required reintubation while the abdomen was still open...There would be a temptation to undertake the minimal amount of surgery possible, such as enterostomies in cases of necrotising enterocolitis, when under more controlled conditions, definitive surgery might be possible and subsequent surgery thus avoided. Other factors not addressed by the authors include restrictions on the use of diathermy and of inhaled anaesthetic agents in the neonatal intensive care unit.

However, the concepts raised by this study should not be dismissed out of hand. There may well be specific occasions where surgery in the unit will be the most appropriate option—for example, the very sick, very low birthweight baby with necrotising enterocolitis—but this should be considered only in exceptional circumstances. Such surgery should still be undertaken by specialist paediatric surgeons, and in major centres where the perioperative management can be undertaken by doctors and nurses with appropriate training and experience of neonates coming to surgery. A better outcome for these very sick infants is more likely to be achieved by an improvement in neonatal transport services, by centralisation of their management, and by the provision of dedicated neonatal operating theatres within the neonatal intensive care unit area.

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