

# Surgical procedures performed in the neonatal intensive care unit on critically ill neonates: feasibility and safety

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**BACKGROUND AND OBJECTIVE:** Transferring unstable, ill neonates to and from the operating room carries significant risks and can lead to morbidity. We report on our experience in performing certain procedures in critically ill neonates in the neonatal intensive care unit (NICU). We examined the feasibility and safety of such an approach.

**METHODS:** All surgical procedures performed in the the NICU between January 1999 and December 2005 were analyzed in terms of demographic data, diagnosis, preoperative stability of the patient, procedures performed, complications and outcome. Operations were performed at bedside in the NICU in critically ill, unstable neonates who needed emergency surgery, in neonates of very low birth weight (<1000 g) and in neonates on special equipment like high frequency ventilators and nitrous oxide.

**RESULTS:** Thirty-seven surgical procedures were performed including 12 laparotomies, bowel resections and stomies, 7 repairs of congenital diaphragmatic hernias, 4 ligations of patent ductus arteriosus, and various others. Birthweights ranged between 850 g and 3500 g (mean, 2000 g). Gestational age ranged between 25 to 42 weeks (mean, 33 weeks). Age at surgery was between 1 to 30 days (mean, 10 days). Preoperatively, 19 patients (51.3%) were on inotropic support and all were intubated and mechanically ventilated. There was no mortality related to surgical procedures. Postoperatively, one patient developed wound infection and disruption.

**CONCLUSION:** Performing major surgical procedures in the the NICU is both feasible and safe. It is useful in very low birth weight, critically ill neonates who have a definite risk attached to transfer to the operating room. No special area is needed in the the NICU to perform complication-free surgery, but designing an operating room within the the NICU would be ideal.

Critically ill neonates who require surgery are traditionally transferred to the operating room (OR). The only exception to this approach is the frequently described ligation of patent ductus arteriosus in the neonatal intensive care unit (NICU), which has results similar to that done in the OR.<sup>1-3</sup> Transferring these unstable neonates to and from the OR may be associated with significant morbidity, which may alter the outcome in these already compromised patients. Surgery in the NICU can avoid the mishaps that can occur during transport of the neonate, like discontinuation of monitoring, dislocation of artificial airways, accidental removal of vascular access and hypothermia.<sup>4</sup> Another advantage of performing surgery in the the NICU is the continuity of care by the same intensive care team. In contrast, it has been suggested

that surgery in the the NICU may increase the risk of infection.<sup>1</sup> We report our experience with critically ill neonates operated on in the the NICU over a 7-year period.

## METHODS

A retrospective analysis was undertaken of all neonates who had surgical procedures performed in the NICU at King Khalid University Hospital, Riyadh, Saudi Arabia over 7 years, from January 1999 to December 2005. Our unit had proposed indications for operating on neonates in the NICU, describing the advantages and disadvantages, and submitted this proposal to the ethical committee of the department of surgery, department of anaesthesia, division of neonatology and OR nursing. The proposal was accepted by all. Surgical proce-



**Figure 1.** Operating site in the neonatal intensive care unit.

dures were performed in the NICU when the patients were clinically unstable and/or weighed less than 1000 g and/or were on a conventional high frequency ventilator (HFV) or on nitrous oxide (NO). All surgeries were done as an emergency. Data were collected from medical records on sex, birth, weight, gestation, age and weight at surgery, underlying diagnosis, clinical stability of the patient, procedure performed, complications and outcome. Our NICU has 22 intensive care beds and 20 fresh filtered air changes per hour, which is similar to that of the OR. All procedures were performed at the bedside with an overhead radiant warmer (Hill-Rom Air Shields, USA). Temporary wall partitions were set-up around the operation site (Figure 1). The theatre staff brought all the necessary equipment, instruments, and drapes to the NICU. A circulating and scrub nurse from the main OR attended the surgery in NICU.

Regular activities in the NICU were not suspended during surgery. The surgical team consisted of surgeons, assistants, a neonatologist, an anesthetist, a scrub nurse and a circulating nurse. Monitoring of the patient included continuous pulse oximetry, continuous electrocardiography, continuous heart rate and blood pressure measurements from either an umbilical or peripheral arterial line. Ventilator requirements were monitored and adjusted by the neonatologist. Intravenous anesthetic agents were used in all cases, as no scavenging system for inhalation anesthetics was available. An intravenous opioid (fentanyl) combined with a non-depolarizing muscle relaxant atracurium or vecuronium was used in all cases. The temperature was monitored with a transcutaneous temperature probe. Portable lights pro-

vided illumination. Skin preparation and draping was performed as in the OR. Magnification surgical loupes were used in some cases to facilitate surgical technique. Operative and postoperative management did not differ from standard practice. For all the neonates operated on in the NICU, a staff neonatologist remained in continuous attendance with the patient from prior to surgery until its completion and adequate postoperative stabilization of the patient.

## RESULTS

A total of 37 surgical procedures were performed in the NICU over the period of 7 years. The preoperative characteristics are shown in Table 1. All the neonates operated on in the NICU were on a mechanical ventilator. Thirty patients were on a conventional ventilator and 7 were on an HFV. Nineteen patients (51.3%) were on inotropic support at the time of surgery. The types of surgical procedures are described in Table 2. All patients with diaphragmatic hernia were not fit to transfer to OR because all were on HFV and NO. All the laparotomy patients had necrotizing enterocolitis. Miscellaneous procedures done in the NICU included unilateral or bilateral inguinal hernias, insertion of long

**Table 1.** Preoperative characteristics of the neonates.

	Mean	Range
Birthweight (grams)	2000	850-3500
Gestational age (weeks)	33	25-42
Age at surgery (days)	10	1-30
Use of inotropes		19 (51.3%)
Mechanical ventilation		37 (100%)

**Table 2.** Surgical procedures in the neonates.

Procedures	Number
Laparotomy, bowel resections and stomies	12
Repair of congenital diaphragmatic hernia	7
Patent ductus arteriosus ligation	4
Repair of omphalocele	1
Repair of gastroschisis	1
Minithoracotomy and lung biopsy	1
Tracheostomy	1
Unilateral or bilateral inguinal hernias, insertion of long lines, peritoneal dialysis catheter insertion and muscle biopsies	10
<b>Total</b>	<b>37</b>

lines, peritoneal dialysis catheter insertion and muscle biopsies.

Body temperature was maintained within the normal range for gestational age. The ventilator settings were perioperatively adjusted to maintain arterial saturation between 90% to 96% depending upon the gestational age. Postoperatively, one patient of low birth weight with a perforated necrotizing enterocolitis developed wound infection and wound disruption. There was no perioperative death. There were three mortalities (none related to surgery). One patient with congenital diaphragmatic hernia died 37 days after surgery due to sepsis and two pre-term babies with perforated necrotizing enterocolitis died in the first week after surgery due to sepsis and respiratory failure.

## DISCUSSION

The operating theatre is the ideal location to perform surgical procedures because it provides the required sterility and a natural environment for the surgical and anesthetic team. Stable, full-term neonates who require surgery can often be safely transported to the OR, but the transfer of critically ill, unstable, extremely low birthweight (<1000 g) neonates from the NICU to the OR can cause significant problems and morbidity.<sup>5</sup>

Critically ill neonates are transported to the OR in a transport incubator with a transport ventilator and portable monitors. Usually two or three people are required to move the neonate from the transport incubator to the surgical table. These procedures are repeated postoperatively resulting in at least four distinct transfers with a resulting risk of hypothermia, discontinuation of vital treatment, and monitoring, accidental removal of vascular access and dislocation of artificial airways.<sup>5,6</sup> The respiratory status of the patient is also a factor even without loss of artificial airways. Many neonates are dependent on complicated ventilators or methods of ventilation such as high frequency or oscillation. These highly sophisticated ventilatory modes cannot be continued during transport. In our series, 7 neonates were on HFV and it was not possible to transfer them to OR for surgery. These patients benefited by having surgery done in the NICU. Incompatibility between monitoring equipment in the OR versus the NICU can be another problem.

The journey back from the OR can be particularly hazardous since the baby is often more fragile immediately after surgery. Emergencies such as hemorrhage, arrhythmias, a displaced endotracheal tube or pneumothorax can usually be managed very well in a closely monitored baby on the neonatal unit, but can be a nightmare in a transport incubator being wheeled

along the corridor or in a lift between floors.<sup>7</sup> In view of this, some pediatric surgical centers have used the NICU as an alternative place to carry out surgery in critically ill neonates aiming to reduce the morbidity associated with the transfer.

Surgical procedures on critically ill patients in the NICU avoid such mishaps and morbidities,<sup>3</sup> with the advantage of doing procedures without interfering with monitoring and vital treatment. An additional advantage of performing procedures in the NICU is the continuity of care by neonatal medical and nursing staffs, which is a great asset not only to the patients but also to the anesthetist who may be unfamiliar with the patient's ventilatory and circulatory idiosyncrasies.<sup>8</sup> The movement of newborns on extracorporeal membrane oxygenation (ECMO) can be hazardous.<sup>9</sup>

A major concern over surgery in the NICU is the higher risk of surgical and postoperative infections, although this assumption is not supported by the literature. Taylor et al<sup>10</sup> and Eggert et al<sup>11</sup> reported no wound infection in a series of 79 and 52 patent ductus arteriosus ligations in the NICU. Lally et al<sup>12</sup> compared the insertion of Broviac catheters in neonates in the OR with those in the NICU and found no difference in the incidence of catheter-associated sepsis or positive blood cultures. Gavilanes et al<sup>13</sup> reported no local or systemic infection associated with surgery and no perioperative mortality related to the procedure in his series of 45 neonates operated on in the NICU. Lago et al<sup>14</sup> compared congenital diaphragmatic hernia newborns who underwent surgery in the NICU versus in the OR. In his series, the NICU group had more infectious complications and mortalities, but the mortalities were not related to surgery. The 18 patients operated on in the NICU were critically ill, on HFV and unsuitable to transfer to OR. In our series, 7 newborns with diaphragmatic hernia were operated on in the NICU. All were unstable and on HFV and NO. There was no infectious complication related to surgery in patients operated on for diaphragmatic hernia in the NICU. Finer et al<sup>4</sup> suggested that surgical procedures can be done in the NICU on unstable critically ill neonates with a morbidity similar to that in the OR. In our series, there was no perioperative mortality, but there was one wound infection in a child with perforated necrotizing enterocolitis. The three deaths in our series were due to pre-existing conditions of the neonates or to a cause not directly related to the place of surgery.

In our opinion, successful development of surgery within the NICU requires a clear indication for performing surgery in the NICU, and good planning and cooperation between surgeons, neonatologist, the

NICU and OR nursing staffs. To perform emergency surgery in the NICU, no special area is needed. Surgery can be performed at the bedside in the presence of an experienced pediatric surgeon, neonatologist and anesthesiologist. A designated area, if available, can be used for surgery, and may have higher rate of air circulation, a special ventilation system and no disturbance to routine NICU work.

In conclusion, performing major surgical neonatal procedures in the NICU is both feasible and safe. A maximum benefit is observed in very low birth weight and critically ill neonates who have a definite risk attached to transfer to the OR. No special area is needed in the NICU to perform complication free surgery, but designing an operating room within the NICU is ideal.

## REFERENCES

1. Kuster A, Jouvret P, Bonnet D. et al. Feasibility of surgery for patent ductus arteriosus of premature babies in a neonatal intensive care unit. *Eur J Pediatr Surg* 2003; 13:294-297.
2. Coster DD, Gorton ME, Grooters K, et al. Surgical closure of the patent ductus arteriosus in the neonatal intensive care unit. *Ann Thorac Surg* 1989; 48: 386-389.
3. Hubbard C, Rucker RW, Vasquez R, et al: Ligation of the patent ductus arteriosus in newborn respiratory failure. *J. Pediatr Surg* 1986; 21: 3-5.
4. Fanning NF, Casey W, Corbally MT. In situ emergency pediatric surgery in the intensive care unit. *Pediatr Surg Int* 1998, 13: 587-589.
5. Finer NN, Woo BC, Hayashi A, et al. Neonatal surgery: Intensive care unit vs. operating room. *J. Pediatr Surg* 1993; 28: 645-649.
6. Shenassa H, Jankaran K, Duncan W. et al. Surgical ligation of patent ductos arteriosus in neonatal intensive care setting is safe and cost effective. *Can J Cardiol* 1986; 2: 353-355.
7. Besag FMC, Singh MP, Whitelaw AGL: Surgery of the ill extremely low birthweight infant: Should transfer to the operating theatre be avoided? *Acta Paediatr Scand* 1984; 73: 594-595.
8. Mc Kee M: Operating on critically ill neonates: The OR or the NICU. *Seminar in perinatology* 2004; 28: 234-239.
9. Troug RD, Schena JA, Hersheuson P. Et al: Repair of congenital diaphragmatic hernia during extracorporeal membrane oxygenation. *Anesthesiology* 1990; 72: 750-753.
10. Taylor RL, Grover FL, Harman PK, et al: Operative closure of patent ductus arteriosus in premature in front in the neonatal intensive care unit. *Am J Surg* 1986; 152: 704-708.
11. Eggert LD, Jung AJ, McGough EC, et al: Surgical treatment of patent ductus arteriosus in preterm infants. *Pediatr Cardiol* 1982; 12: 15-18.
12. Lally KP, Hardin WD, Boettcher M, et al: Broviac catheter insertion: Operating room or neonatal intensive care unit. *J Pediatr Surg* 1987; 22: 823-824.
13. Gavilan es AW, Heineman E, Herpers MJ et al: Use of neonatal intensive care unit as a safe place for neonatal surgery. *Arch Dis Child Fetal Neonatal Ed*: 1997; 76: 51-53.
14. Lago P, Meneghinil L, Chiandetti L. et al: Congenital diaphragmatic hernia: Intensive care unit or operating room? *Am J Perinatology* 2005; 22: 189-197.