

REVIEW ARTICLE

Bedside Neonatal Intensive Care Unit Surgery- Myth or Reality!

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ABSTRACT

Neonatal transport is associated with complications, more so in sick and unstable neonates who need immediate emergency surgery. To circumvent these problems, surgery in Neonatal intensive care unit (NICU) is proposed for these neonates. This article reviews the literature regarding feasibility of this novel concept and based on the generated evidence, suggest the NICU planners to always include infrastructure for this. Also neonatal surgical team can be developed that could be transported.

INTRODUCTION

Neonatal surgery in neonatal intensive care unit (NICU) is a novel concept which has the potential to decrease the morbidity, mortality and cost of neonatal care. However, it is still not common because of management (infrastructure, manpower) issues. In this review, we have tried to find and compile the evidence for this in literature and based upon that suggest NICU planners to always include provision of same in their NICU.

MATERIALS AND METHODS

The review of the literature was performed in November 2012 using the Medical Literature Analysis and Retrieval System Online (U.S. National Library of Medicine's life science database; MEDLINE), and Google© search. The MEDLINE search employed both "MeSH" (Medical Subject Heading) and "free text" protocols. Specifically, the MeSH search was conducted by combining the following terms retrieved from the MeSH browser provided by MEDLINE: Intensive Care Units; Neonatal, Neonatal Intensive Care Units; Newborn Intensive Care Units; Infant, Newborn, Diseases/surgery. Multiple free-text searches were performed applying sin-

gularly or in combination the following terms through all the fields of the records: neonatal intensive care unit, neonatal surgery, Laparotomy, patent ductus arteriosus. The related articles related to these searches generated by MEDLINE were also reviewed. Subsequently, the searches were pooled and all articles dealing with surgical intervention of neonates in NICU were included and duplicates were excluded. The authors individually reviewed all the abstracts of the retrieved studies in order to select the papers that were relevant to the review topic. In addition, the reference lists of the included papers were searched for any missing articles. After reviewing the studies, authors analyzed them for indications, results and authors recommendations regarding feasibility of the surgical procedures in NICU. Based upon these authors have also suggested future course of action for further development of this field.

RESULTS

Search of text 'Intensive Care Units, Neonatal, neonatal surgery, Patent ductus arteriosus' yielded 63 articles of which 18 were included. Search of Text 'Newborn Intensive Care Units,

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neonatal surgery, Laparotomy' yielded 17 articles of which 2 were included. After searching related articles and references from these articles, 26 articles dealing with surgical intervention in neonates in NICU were included in study (Table 1, 2).

DISCUSSION

Surgery in neonates is required for a number of conditions, in emergency settings (necrotizing enterocolitis etc.), semi emergencies like congenital diaphragmatic hernia (CDH), esophageal atresia and routine cases like hernia. These neonates may be stable or unstable and many of them may be on mechanical ventilator. In non emergent cases, the neonates can be stabilized and then can be taken for surgery. However, in many emergency situations, surgery may be needed immediately. The surgery of these patients involves shifting to operation theater (OT), and then back from OT to Neonatal intensive care unit (NICU). This may mandate inter-hospital or intra-hospital transport. This needs neonatal transport. The adverse effects of inter-hospital transport of neonates are well documented [1, 27]. These include risk of deterioration especially in ventilated and unstable neonates.

Also, there are country wise differences in organization of neonatal transport units ranging from dedicated transport services to carry out all transfers to adhoc systems provided by big hospitals [28, 29]. This leads to a situation where unstable ventilated neonates are transferred in suboptimal conditions. This is more true for neonates requiring surgery, as all over the world there are stand-alone NICU with no surgical facilities and neonates who need surgery are transferred to centers with facility for neonatal surgery. Intra-hospital transport of critically ill patients is also associated with complications. Although there are no studies in neonates, in an Australian study for critically ill adult patients, serious adverse outcomes including major physiological derangement, patient/relative dissatisfaction, prolonged hospital stay, physical/psychological injury and death were reported [30]. To obviate these problems, operations of sick surgical neonates in NICU

are proposed. The neonates can be operated in NICU where surgical facilities are available or a neonatal surgical team could be developed that could be transported for surgery. The major indications for surgery in NICU are the procedures which are needed in neonates on mechanical ventilator or emergently in an unstable patient. Most of these neonates are premature, very low birth weight (VLBW), may be on prolonged ventilator support [31] and may need surgery for congenital or acquired conditions. These neonates have high risk of transport related complication.

However this has problems related to infrastructure, manpower and patient outcome [26]. In this review article, we have aimed to generate evidence in relation to surgery of neonates in NICU rather than OT.

What neonatal surgeries had been done safely in NICU?

A review of the literature suggest that the since the publication of abdominal laparotomy drain for NEC in 1977 [15] and ligation of patent ductus arteriosus (PDA) in 1982 [1] in NICU, a plethora of surgeries have been performed in NICU. PDA ligation is the commonest surgery that has been safely performed in NICU. The results of PDA surgery are reviewed in Table 1. Since first reported by Eggert et al [1] in 1982 [16], published studies from all around the world (USA, Netherlands, Germany, Taiwan, South Korea, etc.) confirm that a total of 669 neonates with PDA had successful ligation in NICU without any major complication. NICU PDA ligation has been known to be safe as well as cost effective [1-7]. In fact, it is has been reported better than the medical treatment (Indomethacin) [3, 15]. The pediatric cardiothoracic surgical team goes to NICU and performs the surgery avoiding any shifting of the sick neonate, while maintaining the continuity of care (same neonatologist) [9]. In spite of such a large worldwide experience, NICU PDA ligation has not gained universal acceptance as most of the NICU planners do not incorporate the idea of neonatal surgery in intensive units; even basic surgical instruments and not always available in NICU.

Table 1:published article of PDA ligation in NICU

S. no	Authors	Country	Year	Number of cases	Outcome	Remarks
1	Eggerl et al ¹	Utah, USA	1982	79	7 deaths due to prematurity	PDA ligation for preterm babies is safe
2	Taylor et al ²	Texas, US	1986	52	20 (not related to surgery)	Surgery in NICU recommended
3	Shenassa et al ³	Canada	1986	14 – OR 14 – NICU	Similar in both group	PDA ligation in NICU is more cost effective
4	Coster et al ⁴	Des Moines, USA	1989	115	3 deaths not related to surgery	Surgical closure preferred < 33 weeks over indomethacin. Closure performed in the neonatal intensive care unit eliminates transport risks and is ultimately safer and easier than transport to an operating room.
5	Kewitz G et al ⁵	Berlin, Germany	1991	35	Article in German	
6	Hoffmann M et al ⁶	Germany	1991	25	none	PDA ligation for preterm babies is safe
7	Huddleston KR, ⁷		1991		Details not known as no full text found	
8	Mortier E et al ⁸	Gent, Belgium	1996	33	2 deaths not related to surgery	PDA ligation for preterm babies is safe
9	Gavilanes et al ⁹	Maastricht, Netherlands	1997	45	Nil surgery related mortality	NICU is good place to perform surgery and no increased chances of infection PDA = 16 Other cases-Ventricular catheter for hydrocephalus = 14,CDH repair = 2,Lung biopsy = 2,Laparotomies = 12
10	Fanning ¹⁰	Dublin, Ireland	1998	25	36% mortality not related to surgery	Recommends surgery NICU
11	Gould et al ¹¹	Pennsylvania, USA	2003	72	7	It is better that cardiosurgery team goes to referring hospital for PDA ligation in their NICU than referring children to higher centers
12	Kuster et al ¹²	Paris, France	2003	22	Not related to surgery	High-frequency mechanical ventilation in case of severe respiratory failure moribundity can be limited by performing the surgery in an NICU, and by switching from conventional to high-frequency mechanical ventilation in case of severe respiratory failure
13	Lin CT et al ¹³	Hsien, Taiwan	2003	17	3 deaths not related to surgery	surgical closure of the PDA for the premature infant can be a safe and effective procedure performed in the NICU, when indomethacin closure is ineffective or contraindicated.
14	John et al ¹⁴	USA	2007		Assessed several problem areas, including communication issues regarding patient and unit readiness, design of instrument sets, and organization and transportation of surgical supplies and implemented solutions to these problems resulted in a decrease in the amount of time the surgical team spent in the NICU and more efficient surgical procedures	
15	Lee GY et al ¹⁵	Seoul, S Korea	2008	94.VLBW	20 deaths not related to surgery	PDA ligation of VLBW performed in the NICU is safe without serious complications
16	KO Y C et al ¹⁶	Taiwan	2009	41LBW	5 deaths because of prematurity	suggest surgical closure as the primary treatment in very-low-birth-weight infants who are ventilator dependent to avoid the possible complications of indomethacin and prolonged intubation

PDA- Patent ductus arteriosus ,OR- Operation room,NICU - Neonatal intensive care unit; CDH- congenital diaphragmatic hernia

Table 2: Published articles of surgery in NICU

S. no	Authors	Country	Year	Number of cases	Diagnosis & Procedure	Outcome	Remarks
1	Ein et al ¹⁷	Canada	1977	5	NEC Drain	2 Deaths	Peritoneal drainage recommended over open surgery
2	Besag et al ¹⁸	Bedford, UK	1984	2	Not specified	0	Recommends surgery in NICU
3	Lally et al ¹⁹	Los Angeles, USA	1987	31	Central line	Catheter related complications were same as those put in the OT	Recommends central line insertion in NICU
4	Finer et al ²⁰	Alberta,	1993	81	Not specified	1 surgery related death	Recommends surgery in NICU for preterm sick babies
5	Fravley et al ²¹	Victoria, Australia	1999	233	NEC	9 deaths	Surgery in children < 1500g in NICU is recommended.
6	Klotz et al ²²	Rochester, USA	2001	57 patients	Tracheostomy	No complications	Tracheostomy in NICU as safe as in OT
7	Noble et al ²³	Tacoma	2001	8	Peritoneal drainage	4 deaths	Peritoneal drainage is not a definitive treatment but an adjunct
8	Lago et al ²⁴	Padua, Italy	2005	42	CDH	17 deaths	Recommended surgery in NICU for those neonates dependent on HFOV
9	Arbell Det al ²⁵	Jerusalem, Israel	2007	12	NEC	7 deaths	Bedside laparotomies are safe and feasible
10	Mallick et al ²⁶	Riyadh, Saudi	2008	37 cases, critically ill, unstable	Laparotomy, bowel resections and Stoma -12; repair of CDH- 7; ligations of PDA-4; others-14	no mortality related to surgical procedures	Performing major surgical procedures in the NICU is both feasible and safe
11	Parente A et al ²⁷	Madrid, Spain	2009	405	deferred thoracotomy closure-(172); placement of ECMO (42); ligation of PDA-(45); laparotomies for NEC-27; repair of CDH-20; plication of diaphragms (5); closing of gastroschisis -4	No surgical complication related to location of surgery	NICU is a suitable place for surgical interventions in critical patients; less hypothermia in NICU group
12	Hall et al ²⁸	UK	2012	312 operations were performed in 249 infants.	Laparotomy -194; CDH-36; Abdominal wall defect-23; central venous access -16; Tracheostomy-9; TEF-8; Stoma closure-5; Gastrotomy-3; Others-18	No surgical complication related to location of surgery	Operating on NICU is feasible and safe, and a full range of neonatal operations can be performed. Recommend this approach for all ventilated neonates and unstable neonates

Laparotomy for necrotizing enterocolitis (NEC) is the other commonly reported surgery that has been performed in NICU [19]. Most of these are sick unstable ventilated neonates.

Apart from this, CDH repair also has been described (Table 2). Some NICUs have a well-established protocol for operative repair of CDH in NICU [22]. Newborns with CDH symptomatic at birth were sedated and paralyzed in the delivery room, and treated with elective high-frequency oscillatory ventilation (HFOV), surfactant, inhaled nitric oxide (iNO) and membrane oxygenation (ECMO) as necessary, delaying surgical repair until their clinical conditions were stable. Once the CDH newborn was stabilized, a trial on conventional ventilation was started at least 24 hours before surgery; however, if the patient was unstable, therapy was switched back to HFOV and surgery was performed in the NICU. They recommended a prolonged phase of pre-surgery stabilization and strict control of infection for the CDH newborns that might benefit from an exclusive HFOV and NICU surgery.

Table 3 : Organ system wise proposed indication of surgery in NICU

Organ system	Proposed indication
Neurosurgery	posthemorrhagic hydrocephalus in VLBW or LBW neonates-ventriculostomy (VSG) shunt placement and ventricular reservoir placement for intermittent tapping.
Neonatal Thoracic surgery	TEF, CDH, CCAM, CLE, Neurenteric cysts, Tracheostomy
Neonatal Cardiac Surgery	PDA ligation
Neonatal abdominal surgery	Laparotomy for NEC, Intestinal Perforation, malrotation, neonatal intestinal obstruction, abdominal wall defect repair/reduction, stoma creation,
Neonatal genitourinary tract surgery	Urinary diversions(nephrostomy, pyelostomy, ureterostomy, vesicostomy), hydrometrocolpos drainage

Besides, tracheostomy [20], central line placement [17], tracheoesophageal fistula (TEF) repair [26], abdominal wall defect repair [32], stoma closure [26], gastrostomy [26] have been also done safely in NICU (Table 2). A list of surgeries that could be performed in NICU has been tabulated (Table 3).

What are the infrastructures needed for surgery in NICU?

Almost all the NICU have certain basic instruments which are routinely used. These non consumable instruments can be used for surgery also (Table 4). As apparent from the table, very few extra instruments/ infrastructural changes are needed to perform surgery in NICU. All future NICU planners must integrate OT, equipped with the common surgical consumables in NICU.

Table 4: Infrastructure needed for surgery in NICU

Instruments for surgery likely to be available in NICU	Extra instruments needed
Radiant warmer	Neonatal laparotomy set/THORACOTOMY set
LED light	Electrocautery and its accessories
Sterile drapes	Head lamp with LED light
Central oxygen, suction, compressed Air	Nitrous oxide cylinder, Sevoflurane
Neonatal ventilator	
Multi para Monitors(pulse oximeter, ECG, BP)	
Temperature monitoring system	

What are the members needed for NICU operative team?

Every hospital should have a dedicated team to undertake these procedures. A sample team can consist of senior neonatal surgeon, two neonatal surgeons as assistants (one may be trainee), two trained surgical nurses (one scrub nurse and the other floor nurse), one technician to maintain the instruments and two neonatal anesthetists. Each neonatal NICU should have dedicated cupboard for surgical supplies that should be replenished after each surgery.

According to British Association of Perinatal Medicine Standards for Hospitals Providing Neonatal Intensive and High Dependency Care and Categories of Babies requiring Neonatal Care guidelines, level III Units should provide the whole range of medical neonatal care but not necessarily all specialist services such as neonatal surgery [33]. However, they recommend defined lines of communication and access to specialist advice including Neonatal Surgery and Anaesthesia. As neonatal surgery is required only a few of the neonates, this policy of neonatal ICU operative team covering designated level III NICU within a geographical area can be utilized for optimal utilization and greater reach of resources. It has the advantages of maintaining the continuity of care

and minimal inconvenience to mother. With more and more level II and level III NICU being developed all over the world, this policy can solve human resource problems for neonatal surgery.

CONCLUSION

Neonatal surgery in NICU is a safe procedure and can be utilized in unstable or ventilated neonate. Every neonatal ICU planner should always create infrastructure for surgery in NICU. Surgical NICU operative team should be developed for optimal reach and utilization of resources.

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