Personal practice

Transport of the surgical neonate

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SUMMARY We have shown that the critically ill neonate may be safely transferred over long distances provided some essential criteria are fulfilled. There are obvious advantages in centralising neonatal surgery in a limited number of regional centres where surgical expertise and adequate support services are concentrated and there seems to be no justification, except in situations of dire emergency, for neonatal surgery to be performed in district general hospitals in the United Kingdom. The fact that neonates requiring surgery can be safely transferred adds strength to the plea for the paediatric surgeon to have an absolute monopoly of surgery in this age group.

Neonatal surgical care in the United Kingdom has been concentrated in specifically designated regional centres, and it is only in such centres that paediatric surgeons, managing a sufficient volume of diverse congenital anomalies, acquire the surgical expertise necessary to attain acceptable results. The value of the various support services (paediatric, anaesthetic, radiology, pathology, nursing and ancillary services) in these centres should not be underestimated. The requirements for postoperative care, mechanical ventilation, and parenteral nutrition in the severely ill neonate can best be met in these regional centres. In spite of the obvious advantages of the neonatal surgical units a reluctance to transfer newborn infants remains; firstly because of possible complications that may develop during transportation, and secondly because of the theoretical adverse effect on maternal-infant bonding. It is our impression that there are few, if any, adverse effects on bonding but a retrospective and prospective comprehensive study of this problem currently in progress at this hospital should clarify the situation.

To assess whether infants suffer adversely from being transferred to regional centres, a prospective study of 100 neonates consecutively admitted to the Hospital for Sick Children, Great Ormond Street, was conducted. The series began in August 1982 and ended in February 1983.

Methods

A retrieval service for collecting surgical neonates from referral units has yet to be established at this hospital. The following set of instructions are issued to the referral team:

(1) The infant should be transferred in a transport incubator to prevent hypothermia. Under ideal circumstances facilities should be available for monitoring of the infant's temperature, heart rate, and inspired oxygen concentration. Mechanical ventilation is required for the critically ill infant and particularly for infants with diaphragmatic hernia and respiratory distress syndrome.

(2) Nasogastric decompression is essential for all infants with intestinal obstruction but is also recommended for all surgical neonates to prevent vomiting and aspiration. A size 8 FG calibre tube is suitable for term infants but size 6 FG is more appropriate for preterm babies. The tube should be aspirated at frequent intervals to ensure that the stomach is evacuated of all its contents and should remain patent and on free drainage. A tube that is spigotted may promote reflux and is therefore more dangerous than no tube at all.

(3) Copies of all relevant medical and nursing notes including details of the pregnancy and delivery should be sent to the regional centre.

(4) Radiographs and results of all relevant sero-

logical and bacteriological investigations should accompany the infant.

(5) A valid consent for surgery should be immediately available. Ideally, the father should accompany the infant in order to discuss the planned procedure, but this may be impractical as he may be needed to care for the rest of the family at home.

(6) A 10 ml specimen of clotted maternal blood will reduce the amount of infant's blood necessary for cross matching purposes. All neonates undergoing surgery require blood to be available for transfusion should the need arise.

(7) Special instructions:

(a) *Oesophageal atresia*

The blind upper oesophageal pouch should be kept empty, ideally by means of a double lumen Replogle tube maintained on continuous suction. This may be difficult to achieve during the ambulance journey and a wide calibre naso-oesophageal tube, aspirated at regular intervals (5 to 10 minutes) will achieve the same effect. The infant should be kept in the prone position, which has been shown to reduce gastro-oesophageal reflux into the distal oesophagus most effectively.

(b) *Diaphragmatic hernia*

A large calibre nasogastric tube should be passed immediately on diagnosis. This will restrict the amount of air entering the gastrointestinal tract, thereby minimising compression on the pulmonary tissues. For infants with continuing respiratory distress and particularly for those less than 12 hours of age, endotracheal intubation and gentle mechanical ventilation are essential. Sudden deterioration of the infant's condition is frequently caused by a tension pneumothorax. Needle aspiration of the pleural cavity may be a life saving manoeuvre in these cases.

(c) *Gastroschisis and exomphalos*

The exposed intestine is a source of major heat and fluid loss. Both these losses may be restricted by wrapping the infant's torso in several layers of plastic wrap ('cling film'). An intravenous infusion of plasma (20 ml/kg/hour) and broad spectrum antibiotics (penicillin and gentamicin) should be given.

Resuscitation of the shocked infant should be begun at the referring hospital and should continue ideally until the infant's condition has stabilised. There are, however, certain circumstances in which prolonged resuscitation may be counterproductive

and where the delay in surgical treatment may jeopardise the infant's chances of survival (midgut volvulus, intestinal perforations, haemorrhage from a ruptured liver), and in these conditions close collaboration with the regional centre will determine the most propitious time for transfer.

The mother should always be given the opportunity of seeing and handling her newly born infant before the transfer is effected. A polaroid photograph of the infant is of invaluable comfort to her during the difficult and uncertain period of the separation.

Patients

The infants were transferred from maternity units over a wide area encompassing the Greater London area; the Eastern Counties (Essex, Cambridgeshire, Suffolk, and Norfolk) North Kent; Surrey; and the Home Counties (Hertfordshire, Bedfordshire, Buckinghamshire, and Berkshire). Two infants were referred from the British Military Hospital in Hanover, West Germany. Most infants came from the Greater London area—30 from within a 10 mile radius of the hospital. Fig. 1 shows the distance of the journeys, while duration is shown in Fig. 2. The mean distance travelled was 40.98 miles with a range of 1 to 450 miles. The mean duration of the journey was 69.09 minutes, range 10 to 510 minutes. The age of the patients on admission is shown in Fig. 3. The mean age was 65.75 hours, range 2 to 420 hours (17 days). Fifty patients were admitted on the first day

Fig. 1 Distances (miles) during the transfer of surgical neonates. (Mean, 40 miles).

Fig. 2 Duration of the journey (minutes). (Mean, 69 minutes).

of life—35 were less than 8 hours old. Mechanical ventilation was required during transportation in 14 infants. A breakdown of the diagnoses of the neonates is shown in Table 1.

The circumstances of the transfer were graded according to the physical condition of the infant on admission and whether all the relevant instructions had been followed. An optimal result was obtained in 53 infants, suboptimal in 45, and two were classed as complicated. One infant with a diaphragmatic hernia died during transfer. This infant was transferred from a unit 125 miles away and the ambulance journey lasted 135 minutes. Three regional centres at closer range were unable to admit the infant. A second infant vomited and aspirated during transfer but was successfully resuscitated. The areas of deficiency in the suboptimal group are shown in Table 2 and in many of these more than one of the criteria was unsatisfactory.

The mean core temperature on admission was

Table 1 Diagnoses in the 100 neonates

Oesophageal atresia	15
Diaphragmatic hernia	10
Intestinal obstruction	23
Anorectal anomaly	11
Hirschsprung's disease	3
Exomphalos/gastroschisis	9
Necrotizing enterocolitis	10
Spina bifida/hydrocephalus	7
Genitourinary anomaly	5
Neonatal tumour	2
Pulmonary problem	2
Miscellaneous	3
Total	100

Table 2 Circumstances of transfer, and deficiencies

Transfer	
Optimal	53
Suboptimal	45
Complicated	2*
Areas of deficiency	
Referral details	32%
Radiographs	7%
Nasogastric tube	24%
Consent	10%
Maternal blood sample	10%
Hypothermia	14%

* Aspiration (1); diaphragmatic hernia, died (1).

36.48°C, range 33°C to 39°C (Fig. 4). Fourteen infants were hypothermic (as defined by a body temperature of less than 36°C) on admission. Ten of these infants were less than 24 hours old and there is a statistically significant correlation between age and hypothermia (χ^2 $P < 0.001$). A defect in the anterior abdominal wall was present in four of these infants and three had diaphragmatic hernias. All four infants admitted after the first day of life had an intestinal perforation—three necrotising enterocolitis and one meconium peritonitis.

Fig. 3 Age of the infants. (Mean, 65 hours). Thirty five of the 50 infants admitted within the first 24 hours of life were less than 8 hours old.

Fig. 4 Core temperature of the infants on admission to the neonatal surgical unit.

Referral details, which include both medical and nursing information, were inadequate in 32% of the transferred infants. Essential radiographs were not immediately available in 7% which resulted in either delay in establishing the diagnosis or repeat investigations.

In 14 infants the nasogastric tube was either too small to permit effective decompression or clamped, allowing gastric contents to accumulate exposing the infant to the risk of vomiting and aspiration. In 10 infants without a nasogastric tube in position on admission, five had defects of the abdominal wall, three had intestinal obstruction, and one each had necrotising enterocolitis and an abdominal mass.

Mortality

There were 10 deaths in this series. One infant died during transportation and five infants, admitted within the first 6 hours of life with diaphragmatic hernias, died in the early postoperative period. The remaining deaths were due to peritonitis from an intestinal perforation (two patients), extreme prematurity, respiratory distress syndrome, and oesophageal atresia (one patient) and multiple congenital anomalies including exomphalos major (one patient). Mechanical ventilation was required during transportation in 8 of these patients, reflecting the critical condition of the infants before transfer. Temperature on admission did not differ significantly from the rest of the infants in the series.

Discussion

The transportation of ill newborn infants can be safely achieved provided adequate resuscitation is carried out at the referral centre and these measures are continued during the transfer process.¹⁻³ Most 'medical' neonates transferred to special centres require respiratory support for hyaline membrane disease or recurrent apnoeic attacks or extreme

prematurity, or all three. The need for respiratory support is reflected in the high proportion of 'medical' neonates requiring mechanical ventilation during transfer—as many as 50% in some series.^{4,5} The demands in terms of medical and nursing personnel and monitoring devices is extremely high.⁴⁻⁷

In contrast, infants with surgical anomalies, with the exception of those causing respiratory distress, are less critically ill and do not require the same degree of sophisticated medical attention and careful monitoring. In this series only 14% of infants were mechanically ventilated during transportation. All 6 infants with diaphragmatic hernia, requiring mechanical ventilation during transfer, died. Three of the remaining 6 infants developed respiratory embarrassment after an intestinal perforation and three had hyaline membrane disease in addition to their surgical problem.

Although an optimal transfer was achieved in only 53 cases, most of the deficiencies in the 45 sub-optimal transfers consisted of irritating omissions such as inadequate referral notes and unavailability of radiographs, consent for surgery, and maternal serum. The most serious deficiencies were hypothermia (14 patients) and problems relating to the nasogastric tube (24 patients). Hypothermia, as defined by a body temperature of less than 36°C, was present on admission in 14 patients. Ten of these infants were transferred in the first day of life, four with defects in the anterior abdominal wall and three with diaphragmatic hernias. All four infants with hypothermia who were older than 24 hours had an intestinal perforation. In our opinion, transfer of neonates with impending intestinal perforation should be effected as soon as possible. A policy that delays transfer until perforation has occurred is to be condemned as it exposes the already critically ill infant to the hazards of hypothermia and septicaemia (as a consequence of the ensuing peritonitis), and inevitably increases the interval before surgery can be performed.

The presence of a functioning nasogastric tube of adequate size reduces the risk of vomiting and aspiration during transportation. The referring hospital is given precise instructions regarding the insertion of a nasogastric tube, particularly in neonates with an intestinal obstruction, but despite this 10 infants were admitted without any tube in situ and in a further 14 the nasogastric tube was either too small or was clamped.

The advantages of concentrating neonatal surgery in a limited number of regionally designated centres are clearly seen. Although improvements in the transportation of infants to these centres are still required,^{8,9} most infants are admitted in good

clinical condition. The results in this series further justify the concept that all neonatal surgery should be performed by paediatric surgeons working in specifically designated centres.

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