Transportation of sick neonates, 1972: an unsatisfactory aspect of medical care

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Summary: An analysis of personnel and facilities used for transfer of sick newborn infants to the Neonatal Intensive Care Unit of The Hospital for Sick Children, Toronto during the months November 1971 and February to April 1972 showed many deficiencies. In many instances severely ill patients were accompanied by inadequately trained staff, transport incubators were either inadequate to maintain the babies' temperatures or were used inappropriately, resuscitation facilities were not available and oxygen concentrations could neither be measured nor varied as desired.

Infants who weighed less than 1500 g. at birth and who died following transfer had significantly lower mean body temperatures on arrival at the referral hospital than those who survived. Mean transport incubator temperatures were too low in all groups of infants but were lower in those who died, although the difference was not statistically significant.

Résumé: *Le transport des nouveau-nés malades en 1972: aspect peu satisfaisant des soins médicaux*

L'analyse du personnel affecté au transport des nouveau-nés malades vers le service de soins intensifs aux nouveau-nés du Hospital for Sick Children de Toronto, et l'examen des appareils disponibles, menés durant le mois de novembre 1971 et la période de février à avril 1972 ont révélé de nombreuses lacunes et insuffisances notoires. En de nombreux cas, des nouveau-nés gravement malades étaient sous la surveillance de personnes n'ayant reçu qu'une formation nettement insuffisante, les incubateurs portatifs, ou bien ne permettaient pas de maintenir une température adéquate ou bien étaient manoeuvrés à tort et à travers, il n'existait pas d'appareil de réanimation et les concentrations des oxygénateurs ne pouvaient être ni mesurées ni modifiées au besoin.

La température corporelle, à l'arrivée à l'Hôpital, des nouveau-nés pesant moins de 1500 g à la naissance et qui sont décédés après leur transport était nettement inférieure à celle des enfants qui ont survécu. La température moyenne des incubateurs était toujours trop basse, mais était encore inférieure chez les nouveau-nés qui sont morts. Cette différence était pourtant négligeable sur le plan statistique.

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Regional centres for the perinatal care of mothers and infants who are at high risk are not generally available. Many women whose pregnancies place them in this category will continue to be delivered away from such centres and their babies will have to be transported to a neonatal unit with intensive care facilities. Even when regional centres are developed, 40% of neonatal problems will still be unheralded[1] and most of these babies will have to be transferred to the centre.

The Neonatal Intensive Care Unit of The Hospital for Sick Children in Toronto serves an area including Metropolitan Toronto in which about 55,000 births occur annually. The Unit receives about 1300 babies each year, of whom approximately 60% require intensive care. The referral population has changed considerably over the past 10 years and now includes a higher percentage of low birth-weight infants (<2.5 kg.).

The results of treatment in such neonatal intensive care units are encouraging. The Quebec Perinatal Mortality Survey[2] demonstrated improved infant survival rates when such neonatal units were used. Graven[3] obtained equally impressive results following reorganization of perinatal care in Wisconsin. Long-term morbidity statistics are also accumulating which suggest improved quality of survivors treated in such centres.[4,5]

The effectiveness of a neonatal referral unit depends to a considerable extent not only on adequacy of resuscitation at birth but on management before and during transport. The Canadian Paediatric Society recently published a manual on the transport of high-risk newborns.[6] Lest the importance of this aspect of neonatal care be underestimated we report the results of a recent review of conditions of transfer of high-risk infants to the Neonatal Intensive Care Unit of The Hospital for Sick Children.

Patients

In all, 406 patients were admitted to the unit during the four months of study (November 1971, February, March and April 1972). One hundred and seventy-eight had to be excluded because information collected was inadequate. The remaining 228 babies were allocated to categories according to disease and birth weight and these details, together with the ages on admission, are shown in Table I.

Collection of information

The nurse accompanying the infant from the referring hospital was asked to fill out a questionnaire relating to

referral, mode of transport, facilities available, the infant's condition during transfer and any treatment given en route. On arrival at the unit the admitting nurse or resident recorded the infant's condition. The temperature of the transport incubator was noted unless the patient was so desperately ill that treatment could not be delayed even momentarily. The infant's rectal temperature was recorded immediately on transfer from the transport incubator to a pre-warmed incubator. In many instances arterial blood gases were determined shortly after admission.

Results

Notification of referral

Four percent of the infants arrived unexpectedly. Information was received about the remainder prior to arrival. In only 101 instances did we determine the notifying source. The referring physician had telephoned the neonatal unit directly on 60 occasions but did not always speak to one of the unit's physicians. In 18 instances a nurse from the referring hospital called the unit directly, and in the remaining 23 cases the reservations department of The Hospital for Sick Children had relayed the message to the neonatal unit. Apart from those cases in which the referring physician spoke directly to one of the neonatal unit physicians, information available prior to arrival generally consisted only of the infant's name, weight, name of referring doctor and/or hospital and the reason for referral. Consultation about possible treatment before transportation rarely occurred. Maternal blood for crossmatching accompanied the infant in 50% of cases.

Transit times and means of transportation

The average transit time for patients in each group is shown in Table II. The wide range reflects the fact that the babies came from 49 different hospitals, 29 outside the Metropolitan Toronto area. Twenty of the hospitals in the Metropolitan Toronto area referred 75% of the patients.

Most infants were brought in an incubator and by ambulance. However, 15 infants from nearby downtown Toronto hospitals were brought by taxi while two arrived in the father's car and another two in the referring doctor's car. Small incubators such as the Pragel Portable* were used in these 15 cases. Sixteen infants were wheeled in an Ohio Transport Incubator† from the Obstetric Unit of a hospital linked by tunnel to The Hospital for Sick Children. Ambulances from 10 different firms transported the infants

*H. Pragel Portable Incubators Inc., Baltimore, Maryland
†Ohio Medical Products, 1400 E. Washington Ave., Madison, Wisconsin

Table II—Transit time

Group	Category	Number	Time (mins.) Mean	Range
1	RDS <1500 g.	35	28.0	3 — 110
2	RDS >1500 g.	26	31.0	2 — 180
3	"Uncomplicated" <1500 g.	24	26.5	5 — 130
4	"Uncomplicated" 1.5-2.5 kg.	24	11.5	3 — 45
5	Congenital heart disease	24	54.0	3 — 270
6	Asphyxia, neurological problems	20	34.0	1 — 180
7	Surgical problems	24	36.5	3 — 150
8	Miscellaneous	25	23.0	2 — 150
Total		202	30.5	1 — 270

Table I — Details of 228 infants assigned to 8 disease categories

Group	Category	No. of infants	Birth weight (g.) Mean	Range	Age on admission (hrs.) Mean	Range
1	RDS <1500 g.	37	1240	690 — 1490	4.6	0.5 — 28
2	RDS >1500 g.	32	2139	1570 — 3220	12.75	2.5 — 36
3	Infants <1500 g. without RDS or other major complication	28	1060	600 — 1500	9.0	0.5 — 86
4	Infants 1500-2500 g. without RDS or other major complication	27	1903	1510 — 2470	9.4	0.5 — 77
5	Congenital heart disease	26	2086	1740 — 4740	81.7	2 — 288
6	Perinatal asphyxia and other neurological problems	21	3347	2670 — 4630	19.4	1 — 120
7	Surgical problems	25	2677	1500 — 4168	25.9	1 — 120
8	Miscellaneous*	32	2700	1550 — 4460	7.5	0.8 — 48

*20 infants with respiratory problems other than respiratory distress syndrome (RDS), 4 infants of diabetic mothers, 2 infants with severe erythroblastosis and 6 infants dead on arrival at the referral unit.

Table III — Transport incubators

	No. of cases	No. of temperature measurements	Incubator temperature on arrival Mean °C.	Range	Additional warming devices Hot bottles	Silver swaddler	Both hot bottle and swaddler	None
Ohio Transport Incubator	52	49	34.03	26.7 — 40.0	2	10	0	40
Isolette Incubator Top	39	39	31.00	15.0 — 35.6	6	0	3	30
Airshields Transport Incubator	22	19	32.08	28.9 — 35.0	0	0	1	21
Armstrong Incubator	44	40	28.16	10.0 — 34.0	14	6	0	24
Pragel Portable Incubator	57	52	30.18	15.0 — 36.7	24	10	14	9
Others	7	7	32.69	30.0 — 37.8	1	1	1	4

from hospitals in the Metropolitan Toronto area and the local ambulance from hospitals outside this area.

Facilities available in transit

Several types of transport incubators were used, some more efficient than others in maintaining a stable temperature (Table III). Table IV summarizes the facilities available during the transfer of these infants. One third had no facilities for any form of assisted ventilation. An oral sucker with mucus trap was available in 71.9% of cases. Many ambulances carried mechanical suction but this was inappropriate for the newborn infant. In 17 instances drugs were at hand during transit, caffeine and nikethamide being used in eight cases.

The Hospital for Sick Children "kit" referred to in Table IV was used for some babies transferred from the hospital linked by tunnel; it contains all the essentials for resuscitation of newborns. Although 36 babies had intravenous infusion apparatus *in situ*, in several cases the IV was not running on arrival — in at least two because the ambulance roof was too low to accommodate the stand. No babies were intubated during the journey. In several of those intubated before transfer the tube was found displaced on arrival either into the esophagus or a main stem bronchus.

Table IV — Facilities available during transport

	No.	%
Oxygen	222	97.8
Face mask only	37	16.2
Bag and face mask	114	50.0
Neither bag nor face mask	77	33.8
Stethoscope	66	28.9
Thermometer	30	13.1
Suction (oral, with mucus trap)	164	71.9
Facilities for endotracheal intubation	15	6.5
Drugs:	17	7.4
Analeptics	8	
Sodium bicarbonate (infusion)	6	
Diazepam	1	
Hydrocortisone (infusion)	1	
The Hospital for Sick Children kit	3	
Intravenous infusion	36	15.7
Infants intubated prior to transfer	9	3.0

Accompanying personnel (excluding ambulance attendants)

A nurse alone accompanied 190 infants, a doctor alone 4 infants, and a nurse and a doctor 34 of the 228.

Eighty percent of the nurses had had some experience nursing neonates but many had not been caring for the infant they accompanied. Some were delivery room nurses, others had been taken off adult or children's wards to make the transfer. These nurses were able to convey little or no information about the infant's condition and treatment before transfer.

Condition of infants in transit

The condition of 152 infants was described as being satisfactory during transfer. Seventy-six infants were noted to have been cyanosed and were given additional oxygen in concentrations which were not measured during transfer in any instance. Thirty-four of the 76 were either apneic before transfer or became apneic in transit. In nine cases the apneic infants had been intubated before transfer and received assisted ventilation via an endotracheal tube during the journey; two of the nine were dead on arrival. Of the other 25 apneic infants, ventilation was assisted by bag and face mask in six, of whom two were dead on arrival. Apnea in nine was presumably not severe since a bag and mask were available but were not used. No facilities for assisted ventilation were provided for the remaining 10, two of whom were dead on arrival.

Condition of infants on arrival

Arterial blood gas concentrations were determined as soon as possible after admission to the Unit (Table V), and were obtained before treatment was instituted except when the infant required immediate resuscitation. Of the many patients admitted with significant derangements of acid-base balance, only six were receiving sodium bicarbonate intravenously. Figures for PaO_2 are omitted from Table V because they cannot be interpreted apart from the concentration of inspired oxygen, which varied from infant to infant. The concentration of inspired oxygen ranged from that of room air to 100%. In an attempt to assess if oxygen concentrations offered infants in transit were appropriate we studied the 77 patients for whom the transport incubator oxygen concentration was recorded and for whom blood gas levels at a known inspired oxygen concentration (FIO_2) were determined immediately after admission. The FIO_2 was so low in 26 that the infant was almost certainly hypoxic in transit, and so high in 20 that dangerous hyperoxia probably occurred. In 31 instances the oxygen concentration was appropriate. Therefore almost 60% of these 77 babies were probably exposed to inappropriate oxygen concentrations in transit.

Table V — Blood gas data on 158 infants, obtained from arterial samples taken from radial or umbilical arteries shortly after admission

Group	Category	No.	pH		PCO_2		Base excess	
			Mean	Range	Mean (mm. Hg)	Range	Mean (mEq./l.)	Range
1	RDS <1500 g.	36	7.16	6.90 — 7.47	53.9	25 — 92	−10.4	+ 0.9 to −22
2	RDS >1500 g.	32	7.22	6.84 — 7.37	48.5	30 — 84	− 8.8	0 to −20
3	"Uncomplicated" <1500 g.	17	7.28	6.98 — 7.48	39.4	19 — 78	− 7.0	+ 1 to −18
4	"Uncomplicated" 1.5—2.5 kg.	18	7.32	7.23 — 7.43	34.5	17 — 54	− 6.9	− 2 to −11
5	Congenital heart disease	16	7.33	6.85 — 7.46	32.0	17 — 78	− 8.8	− 4 to −24
6	Asphyxia, neurological problems	10	7.31	7.04 — 7.47	34.3	17 — 58	− 8.1	+ 2 to −18
7	Surgical problems	7	7.30	7.00 — 7.53	36.5	22 — 44	− 7.0	+10 to −20
8	Miscellaneous	22	7.23	<6.80 — 7.41	49.0	22.5 — 94	− 8.5	+ 5 to −20

Temperature data

Table VI shows the mean rectal temperature for each group and the corresponding transport incubator temperature at the time of admission. No significant differences in incubator temperatures between the groups were found. Infants weighing less than 1500 g. who survived had significantly higher temperatures on admission than had those who died. In the larger babies with RDS, group 2, only four infants died, of whom three had temperatures higher than 35°C.; therefore it is unlikely that hypothermia contributed to their mortality.

Mortality

The relationship between mortality and rectal temperature on admission in low birth-weight infants is shown in Table VII. Fifty-three percent of infants <1500 g. were admitted with temperatures <35°C. and 56.6% died, compared with 37% of those with temperatures >35°C. In infants <1500 g. with RDS the mortality was 80% for those with temperatures <35°C. compared to 42.8% for those with more nearly normal temperatures. The difference is not statistically significant. However, in infants <1500 g. without RDS, mortality was 33.3% when the temperature was <35° and 16.6% when it was >35°C., a statistically significant difference ($P<0.05$).

Infants dead on admission

Table VIII summarizes the clinical and transit details of six infants who died during transfer. In Cases 1 and 3 no facilities for assisted ventilation were available. Case 2 was one of premature twins, both with RDS, transported together and accompanied by one nurse with inadequate equipment. The second twin died later.

Discussion

This study took place during four winter months and the results accordingly stress the incidence of hypothermia. However, we considered it important to obtain an analysis during the winter when shortcomings of transport facilities for infants become most obvious.

The circumstances under which the sick neonates were transported to this referral centre did indeed leave much to be desired. Although the numbers are relatively small,

Table VII — Mortality related to admission temperature in low birth-weight infants

	Rectal temperature <35°C.			Rectal temperature >35°C.		
	No.	Died	% Mortality	No.	Died	% Mortality
Infants <1500 g. with RDS	15	12	80	21	9	42.8*
Infants <1500 g. without RDS	15	5	33.3	6	1	16.6**
All infants <1500 g.	30	17	56.6	27	10	37
Infants >1500 g. with RDS	4	1	25	26	3	11.5
Infants of 1500 to 2500 g. without RDS	4	0	0	22	0	0

*0.1 >P >0.05
**P <0.05

Table VI — Infant and incubator temperatures on arrival

Group	Category		Infant temperature No.	Mean °C.	Range	Transport incubator temperature No.	Mean °C.	Range
1	RDS <1500 g.	Died	21	34.48	31.0 — 36.4	19	30.53	15.0 — 38.9
		Lived	15	35.59	33.0 — 39.3	13	32.46	26.7 — 35.6
		Significance		P <0.01			N.S.	
2	RDS >1500 g.		30	36.25	32.0 — 37.8	29	29.90	10.0 — 37.8
3	"Uncomplicated" <1500 g.	Died	6	32.23	31.0 — 36.0	6	31.64	30.0 — 32.2
		Lived	21	34.74	32.0 — 36.7	20	32.16	23.9 — 40.0
		Significance		P <0.01			N.S.	
4	"Uncomplicated" 1.5-2.5 kg.		26	35.75	32.2 — 37.4	26	32.40	24.4 — 40.0
5	Congenital heart disease		23	37.22	35.2 — 38.7	88	30.85	15.0 — 37.8
6	Asphyxia, neurological problems		20	36.77	35.6 — 38.7			
7	Surgical problems		24	36.78	35.1 — 38.7			
8	Miscellaneous		27	35.93	33.4 — 37.5			

Table VIII — Infants dead on arrival at neonatal unit

Case no.	Condition	Age (hrs.)	Birth wt. (g.)	Length of journey (mins.)	Accompanying personnel	Comments
1	RDS with undrained left pneumothorax	29	1960	65	Nurse	Cyanosed in transit. Given oxygen.
2	Premature twin with RDS	6	1000	110	One nurse for 2 twins	As above
3	Meconium aspiration	48	3470	17	Nurse	Apneic in transit. No assisted ventilation.
4	Pulmonary and subarachnoid hemorrhages	17	2460	20	Nurse	Ventilation in transit with bag and mask.
5	Pneumomediastinum and pulmonary atelectasis	20	4460	60	Nurse and doctor	Intubated prior to transfer. Bagged during transfer. Given $NaHCO_3$ 1 ml. IV.
6	Intracranial hemorrhage, undrained pneumothorax	1	1450	40	Nurse and doctor	Intubated prior to transfer. Bagged during transfer.

the results are representative since no other selection of cases took place. The majority of patients were transferred soon after birth although some were as old as 12 days. The mean age of transfer was greater than 24 hours only in the case of babies referred because of congenital heart disease and surgical disorders.

We considered it important to examine the effect of inadequate thermal environment on infants according to birth weight, hence the division into those greater or less than 1500 g. at birth in groups 1 to 4. Although babies from towns as far away as 200 miles were included most had been born in hospitals in the metropolitan area of Toronto. The mean transit time was approximately 30 minutes for most groups. The two exceptions were the infants with congenital heart disease who were referred from a wider area (mean 54 minutes) and the larger infants of low birth-weight without respiratory distress syndrome who were mainly referred from hospitals close to The Hospital for Sick Children.

The range of incubator temperatures which we found is great cause for concern. Likewise, the continued use of hot water bottles as the source of heat can be viewed only with misgiving. In the handbook recently published by the Canadian Paediatric Society[6] the use of certain incubators, especially those requiring heating pads and hot water bottles, is condemned. We found that mean temperatures approach a satisfactory level only in Ohio and Airshields** infant transport incubators and even in these the extremes included values potentially dangerous for the sick neonate, thus illustrating the need for better training of staff in their use.

Furthermore, we found the facilities available during transportation were, in many instances, frankly inappropriate to the seriousness of the baby's condition. Only 3% of the infants had been intubated prior to the journey and in one third no facility was available for any form of assisted ventilation in the event that the child's state deteriorated. A recent report by the staff of a referral centre, describing similar sick neonates, suggests that intubation prior to the journey would have been appropriate in 40%.[7] This figure might be considered too high by many since much may be achieved by appropriate use of bag and mask. Despite the fact that oropharyngeal suction was available in most instances in our inquiry, facilities were inadequate for treatment of major aspiration.

The skill of the person accompanying the sick newborn during transportation is of paramount importance. Eighty-three percent of babies were accompanied by a nurse. Despite the fact that most nurses claimed some experience in caring for newborns few were sufficiently trained to cope with serious deterioration during the journey; in some instances where a bag and mask were available for assisted ventilation the nurse had not been trained to use it.

Some babies were moribund on arrival at the referral hospital. Resuscitation could not be delayed while the study protocol was completed and the blood acid/base data were therefore not recorded. Nevertheless, the figures available give some indication of the severity of illness experienced by many of the infants. Hypoxia, hypercapnia, hypotension and uncorrected metabolic acidosis were common. Frequently all were present in one infant and were compounded by hypothermia. It is clearly impossible for inexperienced personnel to supervise such patients during transportation and unreasonable to entrust such complex problems to them. Such was the disordered haste surrounding transportation of the infants that during the four-month period of study two ambulances were involved in collisions and several nurses required attention for travel sickness on arrival at the referral centre.

Special purpose ambulances for transportation of sick neonates are in use in several centres. Whilst the ideal is yet to be achieved and the sophisticated vehicle may be judged economically unreasonable because of under-utilization, some modification of existing ambulances to facilitate transport of the seriously ill baby is overdue. The most up-to-date general purpose ambulances have lighting, head room, electrical supply and springing inadequate to meet the basic requirements. Compressed air is not available so that assisted ventilation must be carried out with either 100% oxygen or room air. No provisions are made for fixtures to monitor infant temperatures or environmental oxygen concentrations.

Unfortunately, to obtain sufficiently accurate information on the infant's temperature prior to transportation was impossible. The sick neonate responds to thermal stress poorly and doubtless some had suboptimal temperatures before dispatch. However, the fact that the mean temperatures were somewhat lower in the incubators of babies weighing less than 1500 g. who later died, and whose mean temperatures were significantly lower than in survivors, suggests that cooling during transportation was an additional factor affecting the outcome adversely. Kunnas[8] concluded similarly, and in a more extensive study reported mortality to be significantly higher in infants weighing less than 1500 g. when the admission temperature was 34°C. or less.

Conclusion

When considering the advisability of transferring sick neonates to an intensive care referral centre the benefits of referral must outweigh the potential risks of transportation. Such risks may be summarized as follows:

1. Inadequate control of environmental temperature, resulting in thermal stress which is particularly hazardous for the small neonate.
2. Hypoventilation with or without airway obstruction, resulting in hypoxia.
3. Discontinuation of essential monitoring and therapy.
4. Exposure to personnel inadequately trained in the problems of the sick neonate.
5. Inadequate physician communication from the referring to the referral centre.

Transfer of sick babies to this referral centre resulted in undue exposure of the newborn to some or all of the above risks. Corrective measures are now under way. Whilst some improvement in survival will result from the presence of more skilled personnel during transportation, the solution to many of the inadequacies is dependent upon recognition of the seriousness of the problem by the appropriate government and medical agencies. We suspect that our experience is typical, and that other centres also await a solution.

References

1. *Second Report of the Perinatal Mortality Study in Ten University Teaching Hospitals, Ontario, Canada.* Prepared by the Ontario Perinatal Mortality Study Committee. The Ontario Department of Health, 1967
2. *Reports of the Perinatal Mortality Committe of the Province of Quebec,* 1967, part 2 and 1968, part 1
3. GRAVEN SM: *Report of the Joint Committee of the Society of Obstetricians and Gynaecologists of Canada and the Canadian Paediatric Society on the Regionalization of Reproductive Care in Canada.* 1971, p 131
4. RAWLINGS G, STEWART A, REYNOLDS EOR, et al: Changing prognosis for infants of very low birth weight. *Lancet* I: 516, 1971
5. FITZHARDINGE PM, STEVEN EM: The small-for-dates infant. II. Neurological and intellectual sequelae. *Pediatrics* 50: 50, 1972
6. SEGAL S: *Manual for the Transport of High Risk New Born Infants.* Canadian Paediatric Society, 1972
7. STORRS CN, TAYLOR MRH: Transport of sick newborn babies. *Br Med J* III: 328, 1970
8. KUNNAS M: Mortality of premature infants according to the temperature on admission. *Ann Paediatr Fenn* 14: 98, 1968

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