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Reduction of Nosocomial Infection in a Neonatal Intensive Care Unit (NICU)

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ABSTRACT

New measures aimed at reducing nosocomial infection in our neonatal intensive care unit (NICU) were introduced over a 3-month period from 1 July to 30 September 1994.

Objective: The aim of this study was to evaluate the impact of these measures on the incidence of nosocomial infection in our NICU.

Methods: The new measures introduced were:

1. **grouping of all blood investigations to allow for fewer blood samplings per baby per day;**
2. **reduction of routine blood investigations after the acute illness has stabilised, and**
3. **a system of aseptic delivery of drugs through a central venous catheter, thereby reducing the need for peripheral intravenous lines**

Nosocomial infections were defined according to the criteria spelt out in the Centres for Disease Control (CDC) guidelines. Data for the study was obtained from the ongoing surveillance carried out by the hospital's infection control team. Period 1 (1 year duration) was prior to the implementation of the new measures. Period 2 (1 year duration) was after implementation of the new measures.

Results: The overall nosocomial infection patient rates (expressed as number of infections per 100 intensive care unit patients) were 17.6 for Period 1 and 7.5 for Period 2. The overall nosocomial infection patient-day rates (expressed as number of infections per 1000 patient-days) were 13.5 and 6.1 respectively ($p < 0.01$). When the infants' birth weights were stratified as < 1500g, 1500 – 2500g, and > 2500g, the greatest decline in both the overall nosocomial infection patient rate and nosocomial infection patient-day rate was seen in infants weighing < 1500g. There was also a significant decline in the rates of blood-stream infections in infants weighing < 1500g (from 7.5 to 2.8 per 1000 patient-days) ($p < 0.05$). Ventilator associated pneumonias also showed a decline from 3.3 to 1.0 pneumonia per 1000 ventilator days. The organisms responsible for the majority of blood stream infections in Period 1 were methicillin-resistant *Staphylococci Aureus* (MRSA), coagulase-negative *staphylococci*, gram-negative *bacilli* and *candida*. In Period 2, coagulase-negative *staphylococci* was the predominant organism.

Conclusion: We conclude that there was a reduction in nosocomial infection rates. The new measures introduced may have contributed to this reduction.

Keywords: premature, central venous catheter, blood investigation

INTRODUCTION

Nosocomial infection is an important cause of morbidity and mortality[1] in the NICU. In addition, nursery-acquired infections are associated with prolonged hospitalisation and increased cost of neonatal healthcare[2].

With improvements in NICU care, the premature and low birth weight infants have better chances of survival. However, their risk of acquiring nosocomial infection is high[3-5] and this has posed a greater challenge than ever before to staff working in the NICU. In our NICU, nosocomial infection is a problem despite protocols for stringent hand-washing, aseptic invasive procedures and isolation of infected patients. A new strategy to augment existing infection control measures, aimed at further reduction of nosocomial infection was implemented in our NICU over a three-month period from 1 July to 30 September 1994. This study seeks to evaluate the impact of these new measures.

METHODOLOGY

New measures aimed at reducing nosocomial infection were introduced in our NICU over a 3-month period from 1 July to 30 September 1994. These were:

1) Grouping of all blood-taking tasks to allow for fewer blood samplings per baby per day;
2) Reduction of routine blood investigations after the acute illness has stabilised (Table I),
3) A system of aseptic delivery of drugs through a central venous catheter, thereby reducing the need for peripheral intravenous lines.

Parenteral drugs were prepared and connected up in an aseptic manner by our pharmacists under laminar flow condition or by our nurses in the

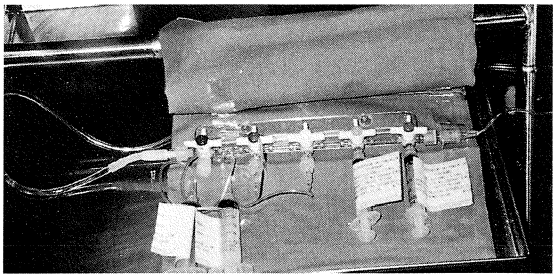

Fig 1 – Central venous line drug delivery system

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Table I – 'Routine' blood monitoring after stabilisation

	Period 1	Period 2
1. Arterial blood gases – on CPAP, low IMV*	3 – 4 x/day	0 – 2 x/day
2. Blood sugar	3 – 4 x/day	1 – 2 x/day
3. Urea and electrolytes	2 – 3 x/week	2 x/week
4. Full Blood Count	} Weekly	Reduced monitoring
5. Liver function test $Ca/PO_4/Mg$	}	

* CPAP = Continuous Positive Airway Pressure
IMV = Intermittent Mandatory Ventilation

Table II – Demographic data

	Total Admissions		
Birthweight (g)	**Period 1 (n-227)**	**Period 2 (n=266)**	**p**
≤ 1000	34	27	0.13
1001g – 1499	40	55	0.46
< 1500	74	82	0.75
1500 – 2500	75	89	0.99
> 2500	78	95	0.83
Birthweight (Mean ± SD)	2093 ± 998	2152 ± 971	0.43
Median	2010	1945	

	Patient Days	
Birthweight (g)	**Period 1**	**Period 2**
≤ 1000	1277	1174
1001 – 1499	866	1002
< 1500	2143	2176
1500 – 2500	485	674
> 2500	315	413
Total	2943	3263

NICU, and then linked to the central venous catheter. This system once connected, was not broken for the next 24 hours. Three-way taps (Fig 1) allow compatible intravenous drugs to be administered at the appropriate times of the day without breaking the closed system. By this means, the need for a peripheral intravenous line was reduced.

Other infection control measures such as hand-washing, aseptic invasive procedures, isolation of infected patients and cohorting of staff were unchanged throughout the 2 study periods.

Definitions for nosocomial infections were in accordance with the criteria spelt out in the Centre for Disease Control (CDC) guidelines[6].

Infection rate indices

Various indices of infection rates have been recommended by the CDC for inter-hospital comparison[7]. The following were used in this study:

1) Overall nosocomial infection patient rate:

$$\frac{\text{No. of nosocomial infections at all sites}}{\text{No. of patients}} \times 100$$

expressed as number of infections per 100 patients (discharged)

2) Overall nosocomial infection patient-day rate:

$$\frac{\text{No. of nosocomial infections at all sites}}{\text{No. of patient-days}} \times 1000$$

expressed as number of infections per 1000 patient-days.

The overall nosocomial infection patient-day rate would at least partially control for variations in length of stay.

3) Device-associated, device-day infection rate:

$$\frac{\text{No. of device-associated infections for a site}}{\text{No. of device-days}} \times 1000$$

expressed as number of device-associated infections per 1000 device days.

4) Birth weight[3,7] was a well recognised risk factor in the NICU, and rates were calculated based on 3 birth weight stratifications; < 1500g, 1500 – 2500g and > 2500g. A further stratification of < 1500g infants to <1000g and 1000 – 1499g infants was done.

Study population

All infants admitted into our NICU during the 2 study periods were included in the study. Period 1 was from 1 July 1993 to 30 June 1994 (1 year duration) and was prior to the implementation of the new measures. Period 2 was from 1 October 1994 to 30 September 1995 (1 year duration), after the implementation of the new measures. The intervening 3-month period of 1 July 1994 to 30 September 1994 saw the implementation of the new measures.

Data for this study was obtained from the ongoing surveillance[8] carried out by the hospital infection control team. This involved review of admission, transfer and discharge records, patient case sheets, microbiology studies and regular submissions of umbilical, central line and ventilator usage in the NICU. Data was collected by the hospital's Infection Control Officer. Monthly reports of overall nosocomial infection patient rate and device-associated, device-day infection rates and etiologic organisms were compiled and circulated amongst infection control staff members and clinicians. This study was retrospective in nature. Medical and nursing staff were only aware of the ongoing surveillance.

Statistical methods

Chi square or Fisher's exact 2-tailed tests were used to test for statistical significance. The Wilcoxon Rank Sum test was utilised for comparison of birth weights of the 2 study populations.

RESULTS

Study population

A total of 227 infants were enrolled in Period 1 and 266 infants in Period 2. There was no significant difference in distribution of birth weights in the 2 periods (Table II).

Table III – Overall nosocomial infection patient rate

Birth weight (g)	Period 1	Period 2
	(Infections per 100 patients)	
Overall	17.62	7.52
≤ 1000	61.76	22.22
1001 – 1499	30.00	9.09
< 1500	44.59	13.41
1500 – 2500	2.67	6.74
> 2500	3.85	3.16

Table IV – Overall nosocomial infection patient-day rate

Birth weight (g)	Period 1	Period 2	p
	(Infections per 1000 patient-days)		
Overall	13.56	6.15	0.004
≤ 1000	15.66	5.11	0.02
1001 – 1499	15.01	4.99	0.048
< 1500	15.35	5.09	0.001
1500 – 2500	4.12	8.90	0.54
> 2500	9.52	7.26	0.94

Table V – Blood-stream infection patient-day rate

Birth weight (g)	Period 1	Period 2	p
	(Infections per 1000 patient-days)		
Overall	8.40	3.37	0.08
≤ 1000	6.26	4.26	0.34
1001 – 1499	9.20	0.99	0.01
< 1500	7.47	2.75	0.023
1500 – 2500	0	5.93	0.11
> 2500	6.35	2.42	0.39

Table VI – Organisms responsible for blood-stream infections

Organism	Period 1	Period 2
	No. of cases	
Methicillin-resistant *staph aureus*	2	
Methicillin-resistant *staph epidermidis*	2	7
Enterococci	1	
Klebsiella	3	
Pseudomonas aeruginosa	2	
E coli	2	
Enterobacter	1	2
Acinetobacter	1	
Serratia	1	
Candida	3	1
Clostridum	1	
Gp B Strept	0	1

Table VII – Distribution of types of infections

Organism	Period 1	Period 2
	No. of cases	
Blood	18*	11
Pneumonia	6	1
Cerebro-Spinal	1	0
Others:		
Urine (Suprapubic Aspiration)	6	0
Chest tube site	1	0
Dripsite	0	1
Necrotising Enterocolitis	2	0
Eyes	4	6
Umbilicus	1	1
Sepsis (clinical sign)	1	0
Total	40	20

* 1 case of blood-stream with 2 infecting organisms identified

Infection rate indices

The overall nosocomial infection patient rate per 100 patients showed a decline from 17.6 in Period 1 to 7.5 in Period 2. The decline is greatest in the < 1500g weight group category (from 44.5 to 13.4) (Table III).

The overall nosocomial infection patient-day rate also declined significantly from 13.5 to 6.1 per 1000 patient-days ($p < 0.01$). Again, this decline was greatest in the < 1500g weight group category (15.3 to 5.1) (Table IV). Blood stream infections also declined from Period 1 to Period 2. In infants < 1500g, blood stream infections declined from 7.5 (Period 1) to 2.8 (Period 2) per 1000 patient days ($p < 0.05$) (Table V). Further stratification for infants < 1500g into 2 weight group categories of ≤ 1000g and 1001g – 1499g showed a significant decline in the overall nosocomial infection patient-day rate in both weight categories (Table IV). Blood stream infection patient-day rate only showed a significant decline in the 1001g – 1499g weight category (Table V).

An increase in the overall nosocomial infection patient-day rate and blood stream infection patient-day rate was noted in the 1500g – 2500g weight group. These however, were not statistically significant ($p=0.54$ and 0.11 respectively) (Table IV and V).

The organisms responsible for blood-stream infections were as in Table VI. In Period 1, Gram negative bacilli, *candida* and MRSA were the main organisms. In Period 2, coagulase-negative *staphylococci* was the predominant organism.

Ventilator-associated pneumonias also showed an improvement from 3.3 (Period 1) to 1.0 (Period 2) per 1000 ventilator days ($p = 0.22$).

Distribution of types of infections in the two periods are as tabulated in Table VII.

DISCUSSION

This study revealed that there was a reduction in the incidence of nosocomial infections in our NICU. This reduction was greatest in the birth weight category of < 1500g infants, who were at the highest risk of infection[3]. The new measures introduced may have contributed to this reduction in nosocomial infection.

Grouping of blood investigations was one important measure adopted which saw the reduction in the number of invasive blood samplings per baby per day. It is logical to infer that a greater number of venous, capillary punctures or arterial line samplings would predispose to a higher risk of nosocomial infections. Therefore an effort was made to co-ordinate blood investigations and grouping them together, especially between change-over staff.

Reduction of routine blood investigations was the other measure introduced. Blood monitoring of infants in their acute stages of illness was similar throughout the 2 study periods. However, when the infant's condition stabilised, the frequency of blood investigations was reduced. This usually occurred beyond the fourth day or the first week of life, when the risk of intra-ventricular haemorrhage in premature infants subsided[13] and the acute respiratory condition stabilised. At this stage, the risk of frequent blood-

taking and nosocomial infection must be balanced against the need for close monitoring. The importance of clinical assessment such as noting a change in the infant's activity or respiratory status cannot be over emphasised. Also, basic clinical care such as meticulous attention to airway and frequent checks to ensure that the endotracheal tube positioning is secure are of great importance. Good basic nursing and clinical care cannot be substituted by blood tests and investigations.

The risk posed by prolonged use of central or peripheral venous catheter is well-recognised[9]. However, in the extremely premature infants, the need for prolonged intravenous alimentation as well as medications often necessitate the prolonged usage of intravenous lines. Setting a peripheral intravenous drip in a small premature infant can be difficult and often involve multiple attempts. This undoubtedly would pose a higher risk of acquiring infection.

In our NICU, a central venous catheter (Silicone, Vygon) is set in infants < 1200g birth weight usually on day 4 of life. This was the practice for the 2 study periods. However, in Period 1, another intravenous peripheral drip was set to allow for infusion of other drugs, such as antibiotics or aminophylline to avoid breaking the close system of the central venous line. In Period 2, these drugs were infused through the central venous line (CVL) connected up in an aseptic manner, hence reducing the need for a peripheral IV drip. Compatibility of these drugs with parenteral nutrition solutions should be checked beforehand. Since the practice was introduced, we had not seen an increase in CVL-related infections, and no CVL had to be removed because of uncontrolled infections during Period 2. In fact, as pointed out, blood-stream infections declined especially in the < 1500g weight category. Central line device use[7] was (No. of device days ÷ No. of patient days) 0.60 (for Period 1) and 0.55 (Period 2) respectively. However, the predominance of coagulase-negative *staphylococci*[10-12] in the latter period, which had been correlated with central venous line usage, had to be monitored closely. Also, the increase in blood-stream infections in infants of 1500 – 2500g in the latter period was noted (Table 5). However, as the number of infections and number of patient-days were relatively fewer, this difference was not statistically significant. In our unit, there is an ongoing programme for audit and monitoring of mortality and morbidities such as necrotising enterocolitis, intraventricular haemorrhage, retinopathy of prematurity and bronchopulmonary dysplasia. It is important to detect any other adverse morbidities associated.

Whilst the study is suggestive of the efficacy of these measures, there are limitations in the intrepretation. One limitation is that the severity of illness of the 2 cohorts had not been analysed. However, it is hoped that by stratification of birth weights, this factor could at least be partially controlled for. Also there may have been other improvements in care which may have impacted on nosocomial infection rates over the 2 study periods. One particular measure is the more aggressive weaning from the ventilator as early as possible with our increased experience with nasal prong continuous positive airway pressure. However, our ventilator-associated pneumonia rates also showed a decline from 3.3 (Period 1) to 1.0 (Period 2) per 1000 ventilator days. Only days on IMV were analysed. Sometimes, an outbreak of infection in a short time frame by one organism can account for a higher infection rate in that period. This factor was excluded after analysing the monthly infection surveillance data.

We also recognise that this study does not report the actual frequencies of blood investigations listed in Table I, the number of blood punctures, and the number of peripheral intravenous drips. This being a retrospective study, there was no detailed documentation in the infant's case-notes of the frequency of the above procedures. However, all clinicians were well oriented with the new measures and as part of the clinical team ourselves, we ensured that the new measures were practised.

We believe that these new measures are in keeping with established principles of good infection control[1]. Our concern is that there must not be a concomitant increase in other morbidities. Hence the approach that we are advocating is one based on careful weighing of the risk-benefit ratio ie. the benefits of more invasive procedures and investigations versus the risk of nosocomial infection. In premature infants, especially beyond the first week of life when the acute respiratory condition has stabilised and risk of intraventricular haemorrhage subsided, the priority shifts to that of prevention of nosocomial infection. Good clinical assessment and basic nursing care instead of excessive reliance on blood tests and investigations cannot be over-emphasised.

In conclusion, there was a reduction of nosocomial infections in our NICU in Period 2 compared to Period 1. The new measures introduced may have contributed to this reduction.

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