

Turn-Around-Time of Radiographs in a Neonatal Intensive Care Unit

J Rohana, MMed(Paed), N Y Boo, FRCP, S C Yong, MRCPCH, L C Ong, MRCP, Third Year Medical Students (Group XI of Year 2002, and Group XI of Year 2003)

Department of Paediatrics, Faculty of Medicine, Universiti Kebangsaan Malaysia, Jalan Yaacob Latif, 56000 Kuala Lumpur

Summary

A quality assurance study was carried out prospectively in two phases at the Neonatal Intensive Care Unit (NICU) of Hospital Universiti Kebangsaan Malaysia. The objectives of the study were to determine the turn-around-time (TAT) of radiographs requested for infants undergoing intensive care treatment in the NICU and the effects of a standard operating procedure introduced based on initial findings of first phase of the study on subsequent TAT. The TAT was defined as the time taken for the radiograph to be ready for viewing after the attending doctor had requested for it to be done on an infant. During phase one of the study, none of the requested radiographs was ready to be viewed by the doctors within the standard TAT of 45 minutes. The problems identified were ward staff's delay in sending request forms to the radiology department, radiographers' delay in shooting and processing the films, and delay by NICU porter in collecting the processed films. Based on these findings, a standard operating procedure (SOP) was drawn up jointly by the staff of NICU and Department of Radiology. During phase two of the study conducted at one month after implementation of the SOP, there was a reduction of TAT by 50%. However, only 3 (4.3%) of the radiographs achieved the standard TAT. The main problems identified during phase two were delay in sending request forms and in collecting processed radiographs by the porter system. The dismal TAT of radiographs in NICU was related primarily to human behaviour. Besides continuous staff education, replacement of the porter system with electronic system may improve the TAT.

Key Words: Turn-around-time, Radiographs, Neonatal Intensive Care Unit, Standard Operating Procedure

Introduction

Radiograph is often crucial in the management of sick newborns in Neonatal Intensive Care Unit (NICU). Chest radiographs are required in some preterm infants to determine the need for administration of exogenous surfactant. At times, changes detected in radiographs help to identify underlying lung pathology in very ill newborns. Chest radiographs also help doctors determine whether optimal lung volume has been attained in sick infants on different strategies of ventilatory support. Other indications for requesting

urgent radiographs in NICU include confirmation of suspected pneumothorax or perforation of gut. Thus, early availability of radiographs requested would greatly help doctors in management of sick infants, with resultant reduction in morbidity and mortality. A short turn-around-time (TAT) of radiographs would therefore enhance the quality of care provided to this group of high-risk infants.

In the NICU of Hospital Universiti Kebangsaan Malaysia (HUKM), the process of getting a radiograph involved several steps. When the attending doctor made a

This article was accepted: 11 October 2004

Corresponding Author: Boo Nem Yun, Department of Paediatrics, Faculty of Medicine, Universiti Kebangsaan Malaysia, Jalan Yaacob Latif, Cheras 56000 Kuala Lumpur

request for a radiograph of a patient, he or she had to sign a request form, which would then be sent to the Radiology Department by the clinical assistant (CA) who provided the porter system. Upon receiving the request form, the radiographer would come to the NICU to shoot the radiograph. The radiograph cassette would then be taken back to the Radiology Department for processing. When the radiographic film had been processed, the CA would then take it to NICU for the doctors to review. Since this NICU was in operation in 1997, the TAT of radiographs was perceived as rather prolonged.

The objectives of the present study were to determine the TAT of urgent radiographs requested for ill infants in this NICU, and the effects of a standard operating procedure introduced based on initial findings of first phase of the study on subsequent TAT.

Materials and Methods

This was a prospective observational study of all radiographs requested for intensive patients admitted to the NICU. The inclusion criteria were sick infants admitted to the 10 intensive beds in the NICU where most of the infants were on respiratory support. This study was carried out in two phases; phase 1 was conducted over a 2-week period (between 25th February and 8th March 2002). Based on the findings of phase 1 during which various causes of delay were identified, a standard operating procedure (SOP) was drawn up jointly by the staff of NICU and the Radiology Department with the aim of improving the TAT of urgent radiographs. The SOP was presented to the staff in NICU and radiology department. Copies of the SOP were also displayed in strategic areas in the NICU. Phase 2 of the study was conducted over another 2-week period (between 19th February and 4th March 2003), one month after implementation of the SOP.

During the study periods, around the clock (inclusive of Saturdays and Sundays), medical students carried out observation and documentation of the whole process of requesting and obtaining radiographs of patients in the intensive care area of this NICU. These students were divided into 4 groups to cover each of the 4 shifts daily: night shift (12am-7am), morning shift (7am-12pm), afternoon shift (12pm-6pm) and evening shift (6pm-12am). The doctors, nurses, clinical assistants working in the NICU and the radiographers were unaware of the study being carried out during both

phases. When questioned, the staff were told that the students were just doing their elective neonatal postings in the ward.

During each shift, the students observed and documented the time taken for each steps involved (as described above) when a radiograph was requested for a patient by the doctors-in-charge. The timing of the TAT began from the time a doctor filled in the request form for a radiographic film for his/her patient, and ended when the requested radiographic film finally reached the NICU for the doctor to review.

The standard set for the turn-around-time was 45 minutes. A review of medical literature revealed no published standard TAT for urgent radiograph in NICUs. The TAT of 45 minutes adopted for this study was based on the standard TAT used by the Neonatal-Perinatal Medicine Subcommittee of the Royal Australasian College of Paediatrics. They set standard TAT from the time the radiograph was requested to the time the film was shot as 30 minutes. During the present study, the standard TAT was lengthened arbitrarily by another 15 minutes based on an estimate of the shortest time required for the radiograph to be ready for viewing by doctors in this NICU. For the purpose of this study, the standard TAT of 45 minutes was divided into 4 intervals:

Interval 1 was the duration between the time a doctor made the written request for radiograph to be done and the time the CA sent the form to the Radiology Department.

Interval 2 was the duration between the time a CA sent the request form to the Radiology Department and the time the radiographic film was shot.

Interval 3 was the duration between the radiographic film was shot and the time a CA collected the film from Radiology Department.

Interval 4 was the duration between the time the CA collected the film and the time the film reached the NICU and ready for the doctors to review it.

The standard duration set was 10, 20, 10 and 5 minutes for Intervals 1, 2, 3 and 4, respectively. An indicator of good quality service was defined as when at least 90% of the radiographs requested were ready for review in the NICU within 45 minutes after the request was made.

The Standard Operating Procedure (SOP)

Based on the problems identified during Phase 1, the following SOP was drawn up. When a decision was made to request for a radiograph of an infant, the attending medical officer would immediately sign a request form. This signed request form would be handed over to the nurse in-charge of the infant. She would then stamp the word "URGENT" on the request form to alert the CA of its urgency who would be directed to send the request form to the Radiology Department immediately. Meanwhile, the staff nurse would inform the radiographer of the need for an urgent radiograph via paging or direct phone call, depending on whether the radiographer was in the Radiology Department at the time of contact. Staff nurses were given written information of the special dedicated phone numbers and pager numbers of the radiographers on-call. Upon receiving the request via phone call or paging, the radiographer would proceed immediately to the NICU to shoot the requested radiograph. The nurse in-charge of the patient would then remind the radiographer to inform the NICU staff once the radiographic film was processed and ready for collection. Once the staff nurse received a call from the radiographer that the film was ready, she would ask the CA to collect the film. The CA would collect the film as a priority and bring it directly to NICU for review by the doctor.

Analysis of data

Comparison of data between the two phases was carried out. The statistical program SPSS (version 10.1) (Chicago, U.S.A.) was used for analysis of data. The Chi Square test (or Fisher's exact test for expected value of less than 5) was used for analysis of categorical variables and Mann-Whitney U test for continuous variables with skewed distribution. The unpaired Student's t test was used for analysis of continuous variables with normal distribution. All statistical tests were two-tailed. P values of less than 0.05 were considered statistically significant.

Results

There were 40 radiographs done during Phase 1 and 69 radiographs during Phase 2 of the study. There was no significant difference in the indications for radiographs done between the two phases (Table I) ($p > 0.05$).

Table II compares the median duration of intervals and proportions of radiographs that achieved standard TAT between the two phases. Following the introduction of

the SOP, there was a significant reduction in the median duration of time spent during each of the Intervals 1, 2 and 3 of Phase 2 when compared with Phase 1 ($p < 0.001$). Furthermore, there was also a significant reduction in the median total TAT during Phase 2 when compared with Phase 1 ($p < 0.0001$).

No radiographs requested achieved the standard TAT of 45 minutes during Phase 1. During Phase 2 only three (4.3%) radiographs achieved the standard TAT; two of these radiographs were requested during office hours and one was requested after office hours. When compared with Phase 1, there were significantly greater proportions of radiographs achieving the standard times during Intervals 1, 2 and 3 of Phase 2 ($p < 0.05$). However, there was no significant difference in the proportion of radiographs achieving the standard time during interval 4 between the phases.

Table III compares the reasons for the delay during Intervals 1-4 between the two phases. Following the introduction of the SOP, there was a significant improvement in the proportion of radiographs that attained the standard time during phase 2 (37.7%) than phase 1 (12.5%) ($p = 0.01$). The activities of the CA accounted for the major reasons for delay in achieving standard time of Interval 1 during both phases. Although the proportion of radiographs that did not meet standard time due to activities of the CA was less during phase 2, the difference was not statistically significant ($p > 0.05$).

Following the introduction of the SOP, there was a significant improvement in the proportion of radiographs that met the standard time of Interval 2 during Phase 2 ($p = 0.02$). However, the main reason for delay during Interval 2 in both phases continued to be due to the fixed schedule of radiographers to provide service in the NICU despite urgent request. There was a significant reduction in the proportion of radiographs being delayed due to "other reasons" during Interval 2 of Phase 2, the exact nature of these "other reasons" was not clear.

The reason for the delay during Interval 3 of Phase 1 could not be determined in 50% of the radiographs. This is because the staff in Radiology Department did not routinely record the time when the radiographic films were ready for collection and the time when the CA collected the films. With the introduction of the SOP, there was a significant improvement in the proportion of radiographs that met the standard time of

Interval 3 during phase 2 ($p=0.002$) although this proportion was still low, being less than 50%. The major reason identified accounting for the delay during both phases was the fixed schedule of the CA to collect processed films from the Radiology Department.

There was no significant improvement in the proportion of radiographs that met the standard time of Interval 4 between the two phases ($p>0.05$). During Phase 1, more than 70% of the radiographs were delayed due to unknown reasons. The exact reason why it took more than 5 minutes for the radiographic films to reach the ward after the CA to collect them could not be determined because following the CA to collect the films was not included in the methodology. During this phase of the study, it was also found that

only 1 out of the 40 request forms was stamped URGENT. During phase 2, there was a significant reduction in the proportion of radiographic delay due to unidentified reasons. When questioned, the CA reported that they had to perform other tasks such as sending specimens to the laboratories and collecting laboratory results as well as collecting the radiographs. A significantly higher proportion ($n=25$ or 36.2%) ($p<0.05$) of the request forms were stamped URGENT during Phase 2 than during Phase 1, although this number was still low from the practical point of view.

There was no difference in the TAT for radiographs requested during or after office hours during both Phases 1 and 2.

Table I: Comparison of indications of radiographs requested during the two phases of the study

Indications for radiographs	Phases of Study	
	I N=40 (%)	II N=69 (%)
To determine types of lung pathology	18 (45.0)	27 (39.2)
To assess position of tips of UAC/UVC inserted	1 (2.5)	4 (5.8)
To assess progress of lung pathology	9 (22.5)	19 (27.5)
To evaluate bowel abnormalities	6 (15.0)	0
Others	6 (15.0)	19 (27.5)

Note: UAC= umbilical arterial catheter; UVC= umbilical venous catheter

Table II: Comparison of median duration and achievement of standard turn-around-time during each of the time intervals and overall turn-around-time (TAT) between phase I & II of the study

Intervals	Median duration (IQR) in minutes			No. of radiographs which achieved standard TAT (%)		
	Phase I N=40	Phase II N=69	P values	Phase I N=40	Phase II N=69	P values
1	47.5 (57)	15.0 (22.5)	0.001*	5 (25)	26(39.7)	0.01*
2	157.0 (174.3)	70 (135.0)	<0.0001*	1(2.5)	15(21.7)	0.01*
3	N=23 108.0 (35.0)	45.0 (52.5)	<0.0001*	0(0.0)	14(20.3)	0.006*
4	N=23 5.0 (27)	10.0 (20.0)	0.1	12(30.0)	20(29.0)	0.9
Total TAT	N=40 410.5 (246.8)	220 (160.0)	<0.0001*	0(0.0)	3(4.3)	0.3

Note: IQR= interquartile range; * denotes statistical significance.

Table III: Reasons for delay during Intervals 1,2,3 and 4 between the two phases of study

	Interval 1		Interval 2		Interval 3		Interval 4	
	Phase 1 n=40	Phase 2 n=69	Phase 1 n=40	Phase 2 n=69	Phase 1 n=40	Phase 2 n=69	Phase 1 n=40	Phase 2 n=69
	No. (%) of radiographs		No. (%) of radiographs		No. (%) of radiographs		No. (%) of radiographs	
No delay	5 (12.5)	26 (37.7)	1 (2.5)	14 (20.3)	0	13 (18.9)	12 (30.0)	19 (27.5)
Doctor too busy or forgot to fill up request form	8 (20.0)	3 (4.3)						
Nurses busy attending other patients	0	14 (20.3)						
Clinical assistant was too busy	12 (30.0)	10 (14.5)						
Clinical assistant procrastinated	9 (22.5)	5 (7.2)						
Clinical assistant fixed time to send form	6 (15.0)	11 (16.0)						
Radiographer busy in other wards			data not collected	23 (33.3)				
Radiographers fixed time to shoot radiographs			18 (45.0)	28 (40.6)				
Delay in processing film					3(7.5)	3(4.3)		
Radiographer did not inform NICU that film was ready for collection					0	5 (7.2)		
Clinical assistant was too busy to collect film					5 (12.5)	data not collected		
Clinical assistant collected film at fixed time					12 (30.0)	28 (40.6)		
Nurse failed to remind CA to collect film					data not collected	13 (18.9)		
Clinical assistant doing multiple tasks							data not collected	33 (47.9)
Others/unknown			21(52.5)	4 (5.8)	20(50.0)	7(10.1)	28(70)	17(24.6)

Discussion

The present study confirms our previous impression that the TAT of radiographs in the NICU of this hospital was unacceptably long. The main reasons for delay were related to human behaviour. These included delay by CA in sending the request forms to the Radiology Department, delay by radiographers to shoot the films, and the delay by CA to manually collect the processed films.

The first phase of the study showed that personnel involved in sending the radiographic request forms and collecting the processed films (i.e. the Clinical Assistants) were the main reason (accounting for 67.5%, 42.5% and 100%, respectively) of the delay during intervals 1, 3 and 4. The inflexible time for shooting radiographs by the radiographer was another important factor.

The results of the second phase of the study showed that with the establishment of a SOP there was a significant improvement in the proportion of radiographs that achieved standard time and a reduction of mean duration in all intervals except for interval 4. The performance of this last interval was solely dependent on the Clinical Assistants.

Another major cause of delay identified in the second phase of the study was related to the radiographers being either too busy shooting radiographs in other wards or their having fixed times to provide urgent radiographic services in NICU.

After Phase 1 of the study, meetings between neonatologists, radiologists and radiographers were held to draw up the SOP. An important issue highlighted by the radiographers was their acute staff shortage with resultant heavy patient load imposed on them throughout the hospital, including the Emergency Department. Thus, included in the SOP were the radiographers' pager number and telephone numbers to expedite the NICU staff to contact the radiographers once the paediatric doctors made a request for radiographs before the request forms were sent to the Radiology Department. The radiographers were advised to provide their services to the NICU immediately upon urgent request rather than at fixed times of the day. However, they pointed out that their workload in other parts of the hospital at times prevented them from meeting this request. The

improvement of the TAT during Interval 2 of Phase 2 of the present study, which was related to the activities of the radiographers, reflected that concerted efforts were made by the radiographers to improve their service.

As for the CA, there was a need to increase their awareness of the urgency and importance of the role of radiographs in management of sick infants. The ward nurse managers were therefore advised to remind the CA of this importance periodically. The results of the present study during Phase 2, however, showed that this had not much impact on them. The main limitation of our study was our inability to determine accurately the reasons for the delay during interval 4. The exact activities of the CA outside NICU in relation to the delivery of the radiographic request forms were not monitored during the study. Based on these findings, discussions will need to be held with the clinical assistants, in a similar manner as had been done with the radiographers, to find ways of getting the radiographs ready within the TAT. Another limitation of the study was that the second phase of the study was done rather soon after the introduction of the SOP; therefore it was not possible to determine whether its effect on improvement would be sustained.

The introduction of a written SOP resulted in a significant improvement in the TAT, albeit still well below the standard expected of good quality service (i.e. $\geq 90\%$ of radiographs attaining standard TAT). Based on the findings of the present study, we would recommend to the hospital management to either increase the number of radiographers or assign a radiographer dedicated to portable radiographs for acute wards such as the NICU. Other remedial measures include marking the request forms with the word URGENT to alert all involved personnel of the urgency of the radiographs and using alternative methods of sending the radiographic request forms to the Radiology Department. These include utilizing the existing hospital 'tele-lift' to send request forms to the Radiology Department and to retrieve radiographic films back to NICU. Another suggestion would be the installation of electronic software facilities for on-line x-ray requests and reviewing radiographic images and reports. Computerized physician order entry (CPOE)¹ and a filmless electronic imaging practice² have recently been shown to improve turn around time of radiograph in a neonatal intensive care unit (NICU) and emergency room, respectively.

Conclusion

The introduction of a Standard Operating Procedure has resulted in a significant reduction of turn around time (TAT) of radiographs requested for sick infants in the NICU. The main factor contributing to prolonged TAT was related to the level of services provided by personnel involved in sending the request forms and collecting processed films.

Acknowledgements

We wish to thank Professor M A Zulfiqar for her valuable suggestions and comments during the

preparation of the study protocol. The following medical students were involved in this study: Ahmad Shahir bin Mawardi, Ainul Hana bt Ahmad Tajuddin, Kamalia bt Kamarulzaman, Karimah bt Ngah, Khor Phay Phay, Loh How Peow, Mohd Adham Shah bin Yeop, Nabila Helwani bt Tamzil, Norhisham bin Salleh, Reymi Marseela bt Abdul Jalil, Saramah bt Mohd Isa, Yussra bin Yusoff, Abdul Qahar bin Abdul Wahid, Mohd Faiz Faizul bin Fauzi, Yap Keat Chian, R Jeyakantha s/o Ratnasingam, Nik Ilyana bt Nik Mohamed Pena, Sharizan bt Mohamed Yusoff, Ismat bt Mohd Sulaiman, Noor Mahazrinna bt Hayadin and Nur Hashimah bt Mat Lazim.

References

1. Cordero L, Kuehn L, Kumar RR, Mekhjian HS. Impact of computerized physician order on clinical practice in a newborn intensive care unit. *J Perinatol* 2004; 24(2): 88-93.
2. Mattern CW, King BF Jr, Hangiandreou NJ, Swenson A, Jorgenson LL, Webbles WE, Orrzynski TW, Erickson BJ, Williamson B Jr, Forbes GS. Electronic imaging impact on image and report turnaround times. *J Digit Imaging* 1999; 12(2 Suppl 1): 155-9.