Utility of daily routine portable chest X-ray in mechanically ventilated patients in the pediatric intensive care unit

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Abstract. The utility of daily routine chest X-rays (CXRs) in mechanically ventilated patients in intensive care units is still controversial. The present study compared the diagnostic, therapeutic and outcome efficacy between daily routine and non-routine (clinically indicated) CXRs in children patients in pediatric intensive care unit (PICU). A prospective randomized study conducted in tertiary center 18-bed PICU, Riyadh Military Hospital, Riyadh, Kingdom of Saudi Arabia. The study selected 52 children, who were mechanically intubated for at least 48 hr. The children were randomized to receive either routine (29 patients) or non-routine (23 patients) CXRs and were followed until extubation or death. Demographic and outcome data were collected and analyzed as appropriate. Although children in the non-routine group received fewer CXRs, the lengths of stay (LOS) in intensive care unit and hospital and mortality rate were nearly the same compared with routine group. The percentage of CXRs with new findings was higher in the non-routine group (83%; 53 CXRs) compared to that in the routine group (69%; 156 CXRs) with an odds ratio (OR) of 2.10 (95% confidence interval [CI] = 0.60–8.11). Also, the percentage of CXRs with new findings that result in intervention was higher in non-routine group (78% vs. 69%; OR = 1.60; 95% CI = 0.50–5.70). The daily routine CXRs was not associated with a reduced effect on length of stay in PICU and hospital or mortality and it does not seem to add any advantages over non-routine CXRs in PICU. Large multicenter studies are needed to confirm these results.

Keywords: Daily routine, chest X-ray, children, intensive care unit, mechanical ventilation

1. Introduction

Chest X-ray (CXR) is one of the most commonly performed investigations in critically ill patients. Lung is the vital organ dealing with oxygenation and any

early information regarding changes in pulmonary pathophysiology is extremely important in the critical management [1]. However, the utility of daily use of CXRs in patients who have been admitted to intensive care units (ICUs) with conditions requiring intubation is still controversial [2].

Some studies have argued for protocols that mandate a daily CXR in intubated patients by claiming that there is a high prevalence of unsuspected findings [3,

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4]. Also, The American College of Radiology recommends routine daily CXRs for mechanically ventilated patients and use of additional CXRs if necessary [5]. Theoretically, routine daily CXRs have two main advantages: Firstly, some life-threatening situations that might otherwise be missed could be discovered and treated. Secondly, length of stay (LOS) in ICU, readmission rate and mortality rate might be positively influenced by this practice [5]. Moreover, elimination of daily routine CXRs might result in on-demand CXRs being obtained more frequently during off-time hours, which may cause an inverse rise of costs [6].

In contrast, other studies have argued that such protocols are not cost-effective and provide no diagnostic or therapeutic advantage over clinically indicated CXR or simple clinical assessment [7, 8], whereas others advocate prescription of CXRs only when warranted by the patient's clinical status [9–11]. Also, some studies have reported a better diagnostic and therapeutic outcome of the non-routine protocol, in terms of CXRs new findings and the new finding that need an intervention [11]. The advantage of the on-demand strategy is that it might avoid unnecessary radiation exposure and provides substantial cost savings [12].

Most of the above mentioned studies were carried out in Western countries and were concerned with the usefulness of daily CXRs in adult patients who have been admitted to intensive care units. Since there is no regional set policy regarding daily routine vs. clinically indicated (non-routine) CXRs and shortage in the studies concerning that issue in our region, particularly in the pediatric ICU, the current study aimed to determine whether there is any difference in diagnostic, therapeutic between protocols utilizing daily routine and those utilizing non-routine CXRs in mechanically ventilated children. Also, the study compared length of intubation, LOS in hospital and ICU as well as the mortality rate in the studied protocols.

2. Materials and methods

An observational prospective randomized study was designed to compare outcome diagnostic, therapeutic and outcome efficacy between protocols utilizing routine daily CXRs and those utilizing non-routine (clinically indicated) CXRs in mechanically ventilated children in PICU. The study included 52 children who were admitted in the pediatric ICU, Riyadh Military hospital, Riyadh, Saudi Arabia, over a 5-month period

from August 2012 to January 2013. The PICU is tertiary center 18- bed.

All children patients who were mechanically intubated ≥ 48 hr were eligible for inclusion in this study. Children patients who were intubated < 48 hr and those who were intubated for > 48 hr but were transferred from an outside hospital were excluded. The selected children were randomized to either routine daily CXR or to the on-demand CXR. Randomization was done according to the last digit of the child medical record number. Children with medical record number ending with either a zero or an even number would be assigned to have routine daily CXRs (routine daily CXRs group). The other children patients whose medical records ended with an odd number were assigned to the group received CXRs only when clinically indicated (i.e., non-routine or on-demand group).

A patient chart was designed for each selected patient to collect demographic data (age, sex, hospital admission diagnosis, and co-morbidities), intubation data (the reason for intubation, date of intubation), CXR data (indication of CXR, the findings noted, and any interventions that were undertaken based on the results of the CXR) and outcome data (date of extubation and date of death and discharge). The PICU team was asked to order routine daily CXRs on the patients randomized to the routine daily CXRs group. A CXR, however, was never denied to any studied patients in both groups requiring urgent CXRs and whenever there was a clinical suspicion of any abnormalities. In this study, portable equipment were used to obtain an anteroposterior view of all CXRs

The PICU teams were also asked to complete the checklist daily during morning work rounds. Whenever indicated clinically, CXRs also obtained by PICU team during morning rounds or by the resident on duty at other times. Daily observation of the selected patients was done until death or extubation. Data on the length of intubation, the duration of the medical PICU and hospital stay were collected and recorded in the patient's chart.

The data were analyzed by using the Statistical Analysis System (SAS) software package [13]. All data were expressed as means ($\pm$ SD), or frequency number and percents. A Mann-Whitney *U* test was used to compare continuous variables and χ^2 and Fischer's exact tests were used in categorical variables as appropriate. Also, multivariate logistic regression models were used to estimate odds ratios and their 95% CIs for the association of the number of CXRs obtained with new

finding as well as those new findings that prompted an intervention with the studied routine and non-routine groups. In that analysis, the non-routine group was considered as the study group. The differences were considered to be statistically significant when the *P* value obtained was less than 0.05. Intention-to-treat analysis was performed in all study analyses.

Approval was taken from the Research Review Committee at Riyadh Military Hospital. Ethical consideration was considered to avoid physical or emotional harm, and to ensure confidentiality and privacy of the collected data and obtaining free informed consent.

3. Results

Of the studied 52 children, 29 assigned to daily routine CXRs group and 23 assigned to non-routine CXRs group. The demographic characteristics of both groups were comparable and most of the studied children were admitted to the PICU because of pulmonary problems (73% in daily routine group and 83% in the non-routine group) (Table 1).

Table 2 showed the comparison of daily routine and non-routine groups according to their progress and outcome. The mean intubation length, length of stay in PICU and hospital stay was nearly the same in the two groups with no statistically significant differences. Also, the percent of death in both groups showed no statistically significant difference (10.34% in routine vs. 13% in non-routine; *P* = 0.31).

Table 3 presented the number of CXRs, its new finding and the finding that need intervention in the studied daily routine and non-routine groups. The mean number of CXRs per person was higher in daily routine group compared with non-routine group (5.4 ± 4.3 vs. 2.3 ± 1.4) with statistically significant difference (*P* = 0.002). However, there were no statistically significant differences regarding new findings obtained from CXRs and the findings that prompted an intervention between daily routine and non-routine groups, although the higher proportion was observed in the non-routine group (83% vs. 69% for the obtained new findings and 78% vs. 69% for the findings that prompted an intervention).

Table 4 presented the odds ratios (ORs) and their 95% confidence intervals (CIs) for the association of

Table 1
Characteristics of the studied children by their randomization arm at the beginning of the study

Characteristics	Routine chest X-ray group (<i>n</i> = 29) <i>n</i> (%)	Non-routine chest X-ray group (<i>n</i> = 23) <i>n</i> (%)	<i>P</i> value
Age, mo (mean $\pm$ SD)	21.4 $\pm$ 33.3	30.3 $\pm$ 43.8	0.42
Sex			
Male	19 (65.5)	17 (74.0)	0.52
Female	10 (34.8)	6 (26.0)	
Comorbidities*			
Cardiac	9 (31.0)	8 (35.0)	0.77
Pulmonary	21 (73.0)	19 (83.0)	0.39
Gastrointestinal	9 (31.0)	7 (30.0)	0.96
Neurology	10 (34.0)	9 (39.0)	0.73
Renal	2 (7.0)	3 (13.0)	0.64
Metabolic	1 (3.5)	1 (4.3)	1.00

*Most patients had more than comorbidity.

Table 2
Comparison of routine and non-routine chest X-ray groups by progress and outcome

Characteristics	Routine chest X ray group (<i>n</i> = 29)	Non-routine chest X ray group (<i>n</i> = 23)	<i>P</i> value
Length of intubation (d) (mean $\pm$ SD)	7.1 $\pm$ 4.8	8.7 $\pm$ 5.7	0.27
Length of stay in pediatric intensive care unit (d) (mean $\pm$ SD)	13.8 $\pm$ 14.3	14.6 $\pm$ 9.8	0.82
Length of stay in hospital (d) (mean $\pm$ SD)	16.7 $\pm$ 16.2	18.7 $\pm$ 10.6	0.58
Outcome			
Death <i>n</i> (%)	3 (10.3)	3 (13.0)	0.31
Discharge <i>n</i> (%)	26 (89.7)	20 (87.0)	

Table 3
Distribution of chest X-ray and its findings in routine and non-routine groups*

Characteristics	Routine chest X-ray group (n = 29)	Non-routine chest X-ray group (n = 23)	P value
Chest X-ray per patient	5.4 ± 4.3	2.3 ± 1.4	0.002
Chest X-ray with new findings			
Yes	20 (69.0)	19 (83.0)	0.34
No	9 (31.0)	4 (17.0)	
Chest X-ray with new findings that prompted an intervention			
Yes	20 (69.0)	18 (78.0)	0.53
No	9 (31.7)	5 (22.0)	

*Data are presented by mean ± SD or n (%).

Table 4
Odds ratios and their 95% confidence intervals for the association of the routine and non-routine groups with chest X-ray

Characteristics	Routine chest X-ray group (n = 29)	Non-routine chest X-ray group (n = 23)	Odds ratio	95% confidence interval
Chest X-ray with new findings				
Yes	20	19	2.10	0.60–8.11 (The reference [comparison] group)
No	9	4	1.00	
Chest X-ray with new findings that prompted an intervention				
Yes	20	18	1.60	0.50–5.70 (The reference [comparison] group)
No	9	5	1.00	

non-routine protocol with the new CXR findings and the findings that need intervention. There has been a non-significant positive association of the new CXR findings with the non-routine protocol. The number of CXRs obtained with new findings was 2.10 times more in non-routine group compared with daily routine group (OR = 2.10; 95% CI = 0.60–8.11). Similarly the CXRs obtained with new findings that prompted an intervention showed 1.6 folds increases in the non-routine group (OR = 1.60; 95% CI = 0.50–5.70).

4. Discussion

The present study compared the diagnostic, therapeutic, and outcome efficacy between protocols utilizing daily routine CXR and those utilizing non-routine (clinically indicated) CXR in mechanically ventilated patients in PICU. The study showed no significant difference between two protocols regarding the studied progress and outcome variables. There was no difference in the mean duration of mechanical ventilation ($P=0.27$), the mean duration of ICU stay ($P=0.82$), and the mean duration of the total hospital stay ($P=0.58$) between the groups of patients received

daily routine and those received non-routine protocol. Also, mortality rate did not significantly differ between the two groups ($P=0.31$).

Similar results were reported in a recent meta-analysis selected eight studies that compared on-demand and daily routine strategies, including a total of 7,078 patients [6]. No difference in ICU mortality, ICU length of stay, and duration of mechanical ventilation was found between the on-demand and daily routine groups, and the meta-analysis highly suggests abandoning routine CXRs. Also, in a large prospective non randomized, controlled study in a 28-bed ICU, Graat et al. [7] have examined the impact of elimination of daily routine CXRs in a mixed medical-surgical ICU on length of stay, readmission rate, and mortality. The authors found no change in the studied outcome factors and concluded that elimination of routine CXRs reduced the number of CXRs in ICU, while not affecting readmission rate and ICU and hospital stay. Furthermore, other previous studies that have examined the same questions reported similar results both in adults [14, 15] and children [12]. In their study with 112 ICU patients, Silverstein et al. [8] found that 3.4% of the patients had unsuspected findings and recommended the use of CXRs when clinically indicated.

However, it is pertinent here to note that in certain conditions with expected high incidence of complications difficult to be diagnosed clinically, the use of routine CXRs is mandatory. Hejblum et al. [9] have reported the mandatory use of routine CXRS in certain invasive procedures such as insertion of endotracheal tube, central venous catheters in neck, chest tube, and during invasive mechanical ventilation for acute respiratory distress syndrome. Hall et al. [3] found that 17.6% of the intubated ICU patients to have new major findings which were not detected clinically. Hence, they reported to use the daily routine CXRs as a standard of care in ICU patients.

The diagnostic and therapeutic value of non-routine CXRs in the present study was higher than that of daily routine CXRs protocol. The new findings obtained from the non-routine CXRs group was higher (83%; 53 CXRs) compared to that obtained from the routine group (69%; 156 CXRs) with an OR of 2.10 (95% CI = 0.60–8.11). Also, the percentage of CXRs with new findings that result in intervention was higher in the non-routine group (78% vs. 69%; OR = 1.60; 95% CI = 0.50–5.70). Similar to our study results, Beke-meyer et al. [15] have reported that an intervention based on a non-routine CXR finding was statistically more common than that of a daily routine CXR.

According to the above mentioned findings, the use of non-routine CXRs protocol in ICU may be of value in reducing cumulative radiation exposure for both patients and health team, and possibly decreased cost. The mean number of CXRs per patient in this study was lower in the non-routine (2.3 ± 1.4) compared with that in daily routine group (5.4 ± 4.3) with statistical significant difference ($P = 0.002$). Taking into consideration the number of CXRs performed per patient during hospital stay, there would be overload not only in the total cost, but also in the radiation dose received by patients and health care workers in ICU [11]. The present study, however, did not specifically examine this question as it is appeared out of the scope of the study.

The present study being a prospective randomized study, the matter, which consolidates the study findings, and prevent the possibility of selection and information biases. The studied two groups were comparable regarding their demographic characteristics and co-morbidities. However, the study was limited by small sample size included, and it did not able to present the outcome by categories of age, sex and morbidity. Also, the complications in the non-routine group might be underestimated in this study as no surveil-

lance was done to determine the delay that would occur between CXR apparent and clinically detected complications. However, because the protocol of this study has stressed to perform CXRs to any patient in both studied groups in urgent conditions and whenever there was a clinical suspicion of abnormalities, the problem of underestimation appeared to have no or minimal importance. Finally, as this study was conducted in only one center, the generalization of its findings is difficult.

In summary, the study findings demonstrated that the utilization of daily routine CXRs protocol in mechanically ventilated children in PICU did not add any advantage over the non-routine protocol. The later showed no increase in mortality, no difference in the duration of ICU and hospital stay compared with daily routine protocol. Moreover, the non-routine protocol was associated with the higher percentage of CXRs with new findings and the findings that result in intervention. Finally, because of small study sample, large multicentre studies are needed, particularly in our region, to confirm these results.

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