

COMPARISON OF DAILY AND ON-DEMAND
PRESCRIPTION OF CHEST RADIOGRAPHS IN
PATIENTS IN THE INTENSIVE CARE UNIT OF A
PUBLIC HOSPITAL IN SELANGOR

BY

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A dissertation submitted in fulfilment of the requirement for
the degree of Master of Medicine (Anaesthesiology)

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ABSTRACT

Introduction : The utility of CXRs in ICU setting in Malaysia is variable with some centres practicing daily CXR strategy where as others practice on-demand strategy. The aim of this study was to compare both daily and on-demand CXR strategy and determine if the current practice of on-demand CXR can be safely continued without affecting the relevant clinical outcomes.

Materials and method : This is a prospective cohort study of mechanically ventilated adult patients admitted to the intensive care units in HSB. The study period was from 1st April 2018 to 30th September 2018.

Result : One hundred and sixty patients were recruited in both daily and on-demand CXR group respectively. There were no statistically significant difference in the duration of mechanical ventilation, ICU length of stay and mortality of the patients admitted to ICU in both groups ($p=0.895$). The mean percentage of CXR with new findings were significantly higher in the on-demand CXR group 83.5 compared to the daily CXR group which had only 38.8 ($p<0.001$). The mean percentage of CXR with new findings that prompted interventions was significantly higher in the on-demand CXR group compared to the daily CXR group, with a value of 83.9 and 34.9 respectively ($p<0.001$).

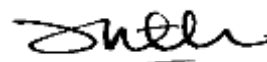
Conclusion : In view of the low diagnostic and therapeutic yield of routine daily CXRs, we conclude that routine daily CXR practice can be safely abandoned in mechanically ventilated ICU patients.

Keywords: *Chest xray practice, Daily, On-demand, ICU*

APPROVAL PAGE

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LIST OF ABBREVIATIONS

ACR	American College of Radiology
ARDS	Acute Respiratory Distress Syndrome
COPD	Chronic Obstructive Airway Disease
CVC	Central Venous Catheter
CXR	Chest Radiograph
ESPEN	European Society of Clinical Nutrition and Metabolism
ETT	Endotracheal Tube
ICU	Intensive Care Unit
LAR	Legally-Accepted Representative
LOS	Length Of Stay
MREC	Medical Research and Ethics Committee
MSV	Millisievert
MYR	Malaysian Ringgit
NGT	Nasogastric Tube
NMRR	National Medical Research Registry
PAC	Pulmonary Artery Catheter
PDT	Percutaneous Dilational Tracheostomy
SAPS II	Simplified Acute Physiology Score
SARS	Severe Acute Respiratory Syndrome
SIMV	Synchronized Intermittent Mandatory Ventilation
SOFA	Sequential Organ Failure Assessment
SOP	Standard Operating Procedure
SPSS	Statistical Product and Service Solutions

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The concept of intensive care unit (ICU) is accepted today as an integral part of almost every public hospital in Malaysia. Intensive care is broadly defined as a service for critically ill patients with threatened or established organ failure, deemed potentially salvageable with relatively good prognosis, who may benefit from more detailed care and invasive treatment (Suh et al., 2015). Amongst many of the diagnostic modalities used in ICU, chest radiography (CXR) plays a pivotal role. The major difference between chest radiography obtained in ICU compared to that in the wards or outpatient setting is ICU patients are critically ill and mechanically ventilated hence requiring the need for portable chest radiography. The advent of portable chest radiography has made the access to CXR readily available thus enabling daily CXR to be done as deemed appropriate by the treating anaesthetist.

There are two different schools of thought regarding the practice of CXR protocols in ICU. Some centres do CXR daily in the mornings of the rounds irrespective of the clinical condition of the patient so that important decisions regarding treatment of patients can be made instantaneously. In contrast, other centres opt for a more restrictive or on-demand strategy which limits CXRs to specific clinical indications such as placement of indwelling devices or a change in the patient's cardiorespiratory status (Krivopal, Shlobin & Scharwartzstein, 2003). As a consequence, standards of care vary from one institution to another and, sometimes, even within a given institution.

The utility of CXRs in ICU setting in Malaysia is likewise variable with some centres practicing the daily CXR strategy where as others practice an on-demand strategy. The variability seen in the treatment strategy here is primarily dependent on the standard operating procedure (SOP) of the respective centres and the clinical experience, preference and practice of the treating intensivists. One of such centre that has been practicing daily CXRs in ICU as part of the hospital SOP is Hospital Sungai Buloh, Selangor. This practice has been under scrutiny of late in view of the potential adverse effects of daily CXRs with regards to patient safety, manpower limitation and cost incurred hence warranting evaluation of our current practice.

The American College of Radiology recommends daily chest radiography for critically ill patients who have acute cardiopulmonary disease or are receiving mechanical ventilation, as well as immediate imaging for all patients who have undergone placement of endotracheal tubes, feeding tubes, vascular catheters, and chest tubes (Suh et al., 2015). This recommendation was made to facilitate early detection of complications associated with malpositioning of indwelling devices as well as timely recognition of cardiopulmonary afflictions that may not be clinically apparent. Furthermore CXR has been a useful adjunct in monitoring disease progression and response to medical therapy especially in some of the recent papers on SARS-CoV-2 infection (Ruan, Yang, Wang, Jiang & Song, 2020; Yuan, Yin, Tao, Tan & Hu, 2020; Wang, Yang, Li, Wen & Zhang, 2020)

The Malaysian Society of Intensive Care does not recommend routine CXR in ICU patients (Lim, 2019) and several other studies have also advocated the benefits of on-demand CXR approach (Al Shahrani & Al-Surimi, 2018). On-demand CXR strategy in ICUs has been shown to reduce radiation exposure to patients and healthcare staff and avoid unnecessary treatment of minor or false positive findings

(Ward et al, 2017)). Furthermore repositioning of critically ill patients during CXRs potentiates the risk of accidental dislodgement of catheters and tubes and promotes microbial dissemination between patients which can be minimised by the strict limitation of radiographs only when clinically warranted (Ioos et al., 2011). In addition, omission of daily CXRs in ICU has led to substantial healthcare cost savings without compromising the quality of medical care and prevent abuse of CXR facilities and manpower.

These studies were however refuted as interpretation of the results were limited by inadequate randomization of patients, investigator bias and ill-defined selection criteria and outcome measurements (Ioos et al, 2011; Ganapathy, Adhikari, Spiegelman & Scales, 2012). A recent meta-analysis conducted comparing daily and on-demand CXR strategy did not show any significant differences in mean duration of mechanical ventilation, length of ICU stay and ICU mortality (Oba & Zaza, 2010; Keveson et al., 2017). In addition, the rate of new findings that prompted therapeutic intervention was shown to be lower in the daily CXR group (Clec'h et al, 2008).

Given these disputes between daily and on-demand CXR strategy, we aim to carry out this study to compare both daily and on-demand CXR strategy and determine if our current practice of daily CXR can be safely abandoned without affecting the relevant clinical outcomes and compromising the safety and care of critically ill patients admitted to our ICU.

1.2 STATEMENT OF THE PROBLEM

This practice of daily CXR for ICU patients in Hospital Sungai Buloh has been under scrutiny of late in view of the potential adverse effects of daily CXRs on patient safety and had recently been changed to on-demand strategy. This study evaluates our

current CXR practice and aim to determine if daily CXR can safely be abandoned without affecting patient safety and clinical outcomes.

1.3 RESEARCH OBJECTIVES

The study aimed to achieve the following objectives:

1.3.1 General

- i. To evaluate the daily and on-demand CXR practice in ICU, Hospital Sungai Buloh, Selangor.

1.3.2 Specific

- i. To compare between the rate of new findings in CXRs (diagnostic efficacy) in daily and on-demand CXR practice.
- ii. To compare between the rate of CXR findings that prompted therapeutic intervention (therapeutic efficacy) in daily and on-demand CXR practice.
- iii. To compare between the mean duration of mechanical ventilation, ICU length of stay, ICU mortality and number of tracheostomised patients in daily and on-demand CXR practice.

1.4 RESEARCH QUESTIONS

This study was conducted to answer the following questions:

1. Is there any difference in the rate of new findings in CXRs (diagnostic efficacy) between daily and on-demand CXR practice?

2. Is there a difference in the rate of new findings (therapeutic efficacy), in CXRs that prompted intervention between daily and on-demand CXR arm?
3. Is there a difference in the mean duration of mechanical ventilation, ICU length of stay and mortality in patients from daily chest radiograph arm compared to on-demand arm?

1.5 RESEARCH HYPOTHESES

It is hypothesized that on-demand radiographs will have higher diagnostic and therapeutic efficacies compared to that of daily CXR. There will be no significant difference in the outcomes such as mean duration of mechanical ventilation and ICU length of stay and mortality between the daily and on-demand study arm.

1.6 SIGNIFICANCE OF THE STUDY

This study aims to determine if the on-demand CXR strategy can be safely continued in ICU Hospital Sungai Buloh in contrary to the initial practice of daily CXR, especially if the current practice does not affect the duration of mechanical ventilation, ICU stay and mortality.

1.7 CHAPTER SUMMARY

This chapter elaborates on the purpose of conducting this study and outlines the objectives, research questions, research hypotheses and the theoretical framework of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

The ordering of CXR in ICU varies and the current predilection of CXR ordering in ICU varies based on the preference of the clinicians. We searched extensively on common indication for ordering of CXRs, side effects of CXR and the relevant clinical outcomes measured including diagnostic efficacy, therapeutic efficacy, duration of mechanical ventilation, ICU length of stay and mortality. In this chapter we will cover all the relevant literature review pertaining to this study.

2.2 INDICATIONS FOR CXR IN ICU

Traditionally obtaining daily chest radiographs in mechanically ventilated ICU patients have been routinely practiced for varying reasons with the primary aim of detecting otherwise unsuspected abnormalities that could potentially alter the clinical course of diseases. In the earlier days, The American College of Radiology (ACR) recommended daily CXRs in mechanically ventilated patients and those with cardiopulmonary issues (McComb et al., 2016). However, emerging new data began to outface this practice disputing the need for routine daily CXR in ventilated ICU patients and its impact on clinical outcomes in this vulnerable population. Oba and Zaza conducted a meta-analysis of eight studies to examine the impact of eliminating routine daily CXR on mortality and length of stay (LOS) in ICU and if there were any specific population of patients that would benefit from this practice (Oba & Zaza., 2010). Out of the 7078 ICU patients analysed, there were no significant difference in

hospital and ICU mortality, LOS in hospital and ICU or duration of mechanical ventilation between the daily and on-demand groups. In addition, regression analyses failed to identify subgroup of patients who would benefit from daily CXR. Another meta-analysis of nine studies involving 39,358 CXRs in a total of 9,611 patients did not detect any harm in adopting on-demand CXR strategy as there were no significant difference in ICU and hospital mortality, LOS in ICU and hospital and duration of mechanical ventilation (Ganapathy et al., 2012). However since the confidence intervals were wide, the safety of abandoning daily CXR was uncertain.

Another two-period cluster randomized trial of 21 ICUs at 18 hospitals was conducted by Hejblum et al. in France to compare the efficacy of daily and on-demand CXR strategies (Hejblum et al., 2009). In the first treatment period, 11 ICUs were randomized to daily CXRs whereas in the second treatment period 10 ICUs were randomized to on-demand CXRs. Out of the 424 patients who had 4607 daily CXR, and 425 patients who underwent 3148 on-demand CXR, there were a significant reduction of 32% in CXR without compromising the safety and quality of patient care. Therefore the current ACR Appropriateness Criteria no longer recommend daily routine CXR in patients with cardiopulmonary problem or stable patients. A web based Delphi study was conducted to explore the opinions of 190 intensivists from 34 ICUs in France regarding indications for CXR ordering in ICUs. Out of the 29 scenarios, 10 involved placement of medical devices, eight with the presence of medical devices and the remaining involved other clinical scenarios. Seventy five percent of intensivists opposed the idea of daily routine CXR in mechanically ventilated patients (Hejblum et al., 2009).

2.2.1 Endotracheal Tubes

Substantial proportions of CXRs in ICU are done due to the presence of endotracheal tubes (ETT). Several studies have evaluated the significance of CXR in confirming placement of endotracheal tubes (Jain , 2011; Koshy, Misra, Chatterjee & Dharan, 2016). Gupta et al. reported that the incidence of ETT malposition is 3% and 14% respectively and bedside CXR have shown to be an easy and quick tool to detect it (Gupta, Jain & Garg, 2014).

The ACR guidelines recommend that CXRs are indicated after intubation as it is able to detect tube malposition in 12-15% of patients compared to 3% detected from physical examination alone (McComb et al., 2016).

However in the recent literatures, this traditional practice of automated CXR post intubation has led to a change in management in only 10% of the cases when compared to a more restrictive approach (Purdy, Purewal, Nathin, Fessler & Kotecha 2020).

2.2.2 Central Venous Catheter (CVC)

Central venous catheterization is routinely done in any ICU setting and has often required radiological imaging techniques to confirm placement. In view of the logistic and financial burden of routine CXR, the practice of ordering a CXR following central venous catheterization has been studied to justify the practice. In a study by Irurhe et al. right internal jugular venous catheterization was performed aseptically in fifty patients by skilled anaesthetist in ICU and post-catheterization CXRs were performed. Approximately 72% patients had correct placement and the remaining 28% had misplacement (Irurhe, Adekola, Desalu, Raji & Peters, 2015). Hence this study was in favour of CXR post CVC insertion.

Post-procedural CXR has been shown to be of tremendous value in identifying malposition or complications of CVC which can be as high as 3% and 14% respectively (Gupta et al., 2014). However some of the recent literature have reported alternative techniques of confirming CVC placement even in paediatric population instead of the traditional post-procedural CXR (Upadhyay et al., 2020).

On the other hand, a study was done by Vallecoccia et al. to assess the feasibility and safety of an echocardiography-electrocardiography guided CVC insertion and to evaluate if the post-insertion CXR can be abandoned. Out of the 80 CVCs that were placed in 78 patients, the post-procedural CXR showed no pneumothorax and 90% of the CVC tips were in the target zone (Vallecoccia et al., 2014). This study concluded that immediate CXR post CVC insertion is unnecessary as placement can be confirmed using ultrasonography.

2.2.3 Pulmonary Artery Catheters

The pulmonary artery catheter (PAC) or Swan-Ganz catheter is a flow-directed balloon tipped catheter which is used to assess and monitor circulatory hemodynamics in critically ill patients in ICU (Whitener, Konoske & Mark, 2014). Major complications of this procedure include pulmonary infarction, cardiac perforation and catheter migration which can be as high as 10% requiring repositioning (Akhtar, Saeed, Mahmood & Sabir, 2016). The ACR guideline recommends CXR following PAC insertion and follow-up CXRs only on clinical indications (McComb et al., 2016).

2.2.4 Nasogastric Tubes

Nasogastric tube (NGT) is commonly inserted in ICU to aid in feeding and aspiration of gastric content. CXR is usually done post NGT insertion to aid in confirmation of its placement within the gastrointestinal tract as inadvertent administration of feed and/or medication into the lungs can lead to fatal sequale (Mathew, Alexander, Patel, & Low, 2019). Several papers have also shown the importance of CXR in early detection of accidental bronchial placement during of NGT to prevent untoward complications (Gachabayov, Kubachev & Neronov, 2016; Najafi, 2016).

2.2.5 Chest Tubes

Chest tube insertion is another common invasive procedure in ICU which is life saving. CXR is routinely done after any chest tube insertion as well as following its removal. ACR guidelines recommend that CXR is done post chest tube insertion to confirm position of the tube as well as detect complications of the procedure (McComb et al., 2016). However some of the recent literatures no longer advocate routine CXR following chest tube insertion unless there are clinical indications (Cunningham et al., 2014; Diaz et al., 2020).

2.2.6 Tracheostomy Tubes

Tracheostomy is a commonly performed procedure in ICU patients with actual and/or anticipated prolonged ventilation, high secretion load or inability to protect the airway. Unfortunately this procedure is not without its complications which includes hemorrhage, pneumothorax, tracheal tear or endobronchial misplacement (Amirian, Shahriarirad, Ziaian, Mardani & Erfani, 2020) hence CXR has been routinely done post-procedure (Cruz, Ferra, Kasarabada, Gasperino & Zigmund, 2016).

Tobler et al. showed that out of 255 patients who underwent tracheostomy, only 4.3% had significant CXR findings with 96% of them having no significant findings that could impact the management (Tobler et al., 2012). A systemic review of the current literature on this topic showed that complication for surgical tracheostomy was 2.2% and percutaneous tracheostomy was 3.2% with only 0.7% and 1.8% of the CXRs performed warranted interventions respectively (Yeo, Phua & Lo, 2014). Therefore the general opinion of these authors seems to favour ordering of CXR only when it is clinically relevant.

2.3 SPECIFIC OUTCOMES

Various outcomes were investigated in many of these studies that compared daily and on-demand CXR strategy and evaluated if there were any differences identified in both strategies.

2.3.1 ICU Length of Stay

A meta-analysis was conducted by Oba & Zaza to determine the effect of eliminating daily routine CXR on ICU length of stay (LOS). A total of 7078 patients from eight studies were identified, 3429 of them had daily CXRs whereas 3649 patients had on-demand CXRs. There were no significant difference in the ICU LOS between the daily CXR and on-demand CXR groups and the weighted mean difference was 0.19 days (Oba & Zaza, 2010). Another meta-analysis was done to evaluate the utility of performing daily CXR in ICU where a total of 9,611 patients from 9 studies were evaluated. Again there was no difference in the ICU LOS between both groups with a weighted mean difference of 0.86 days (Ganapathy et al., 2012).

A prospective study was done by Hendrikse et al. to investigate the effect of eliminating daily routine CXR on ICU LOS. The LOS were categorised into short stay (1-2 days), intermediate stay (3-14 days) and long stay (>14 days). Out of the 589 patients, 349 (61%) had short ICU stay, 179 (32%) had intermediate stay whereas the remaining 39 (8%) had long ICU stay. There were no statistically significant difference in ICU LOS between the daily routine CXR and the on-demand CXR groups (Hendrikse et al., 2007).

A cluster-randomized study by Hejblum et al. in 21 ICUs from 18 hospitals in France also showed that there were no significant difference between ICU LOS in on-demand CXR patients (13%) compared to that of daily CXR patients (14%) (Hejblum et al., 2009). Another prospective study was conducted in two phases in a 28-bed ICU. A total of 2457 daily CXRs and 1437 on-demand CXRs were obtained in the first phase, one month after which second phase was commenced. In phase 2, a total of 2,457 patients received daily CXR whereas 1,437 patients received on-demand CXRs. A prospective randomized study of 94 mechanically ventilated ICU patients whom were similarly randomized to either the daily or on-demand CXR arm also showed no statistically significant difference in ICU LOS between both groups (Krivopal et al., 2003).

2.3.2 Duration of Mechanical Ventilation

There have been several studies that have evaluated the difference in the duration of mechanical ventilation between daily routine CXR and on-demand CXR groups. In general all these studies showed that there were no statistically significant differences in the duration of mechanical ventilation in both these CXR ordering strategies.

Krivopal et al. conducted a study in 94 mechanically ventilated ICU patients, where 43 patients were randomized to daily routine CXR arm whereas 93 patients were randomized to on-demand arm over a period of 10 months. It was shown that the ventilator days for the daily CXR arm was 7.93 +/- 5.64 days versus that in the on-demand arm which was 6.76 +/- 4.03 days. These values too were statistically insignificant (Krivopal., 2003).

In another randomised study by Hejblum et al. in France to investigate 21 ICUs from 18 hospitals, a total of 424 patients received 4607 daily CXRs whereas 425 patients received 3148 on-demand CXRs. The common reason for ventilation in both groups included pneumonia, acute respiratory distress syndrome (ARDS), pulmonary edema, septic shock, asthma and coma. This study showed that patients whom received on-demand CXRs had shorter duration of ventilator days compared to the daily routine CXR group (Hejblum et al., 2009).

Similar results were seen in studies conducted in surgical ICU to determine the utility of daily routine CXRs on the management of patients and the subsequent clinical outcomes. One of such study was done by Resnick et al. involving a total of 197 patients. This study was conducted in two stages, the first stage was where 107 patients were recruited in the daily routine CXR group, after which there was a protocol change to eliminate this daily routine CXR practice. During this second phase of the study, a total of 90 patients were recruited where only on-demand CXRs were performed. There was no significant difference seen in the ventilator-free days between both groups (Resnick et al., 2017). It was concluded that elimination of daily CXRs had no impact on the duration of mechanical ventilation. This finding was similar to a very recent study conducted in ICU population by Purdy et al. which