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Research Article

Cost benefit analysis of portable chest radiography through glass: Initial experience at a tertiary care centre during COVID-19 pandemic

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ABSTRACT

Introduction: Portable chest radiography through glass (TG-CXR) is a novel technique, particularly useful during the COVID-19 (Coronavirus disease 2019) pandemic. The purpose of this study was to understand the cost and benefit of adopting TG-CXR in quantifiable terms.

Methods: Portable or bedside radiographs are typically performed by a team of two technologists. The TG-CXR method has the benefit of allowing one technologist to stay outside of the patient room while operating the portable radiography machine, reducing PPE use, decreasing the frequency of radiography machine sanitization and decreasing technologists' exposures to potentially infectious patients. The cost of implementing this technique during the current COVID-19 pandemic was obtained from our department's operational database. The direct cost of routinely used PPE and sanitization materials and the cost of the time taken by the technologists to clean the machine was used to form a quantitative picture of the benefit associated with TG-CXR technique.

Results: Technologists were trained on the TG-CXR method during a 15 min shift change briefing. This translated to a one-time cost of \$424.88 USD. There was an average reduction of portable radiography machine downtime of 4 min and 48 s per study. The benefit of

adopting the TG-CXR technique was \$9.87 USD per patient imaged. This will result in a projected net cost savings of \$51,451.84 USD per annum.

Conclusion: Adoption of the TG-CXR technique during the COVID-19 pandemic involved minimal one-time cost, but is projected to result in a net-benefit of over \$51,000 USD per annum in our emergency department.

RÉSUMÉ

Introduction : La radiographie pulmonaire portable à travers le verre (TG-CXR) est une nouvelle technique, particulièrement utile pendant la pandémie de COVID-19 (Maladie à coronavirus de 2019). L'objectif de cette étude était de comprendre le coût et les avantages de l'adoption de la TG-CXR en termes quantifiables.

Méthodologie : Les radiographies portables ou au chevet du patient sont généralement effectuées par une équipe de deux technologistes. La méthode TG-CXR a l'avantage de permettre à un technologue de rester à l'extérieur de la chambre du patient tout en faisant fonctionner l'appareil de radiographie portable, ce qui réduit l'utilisation de l'EPI, la fréquence de désinfection de l'appareil de radiographie et l'exposition des technologistes à des patients potentiellement infectieux.

Abbreviations: SARS CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2; COVID-19, Coronavirus disease 2019; PPE, personal protective equipment; TG-CXR, Through Glass Portable Chest Radiograph; USD, United States Dollars; PUI, Persons Under Investigation; ACR, American College of Radiology; RSNA, The Radiological Society of North America; PACS, Picture Archiving and Communication System.

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Le coût de la mise en œuvre de cette technique pendant la pandémie actuelle de COVID-19 a été obtenu à partir de la base de données opérationnelle de notre service. Le coût direct de l'EPI et du matériel de désinfection utilisés de façon routinière et le coût du temps pris par les technologues pour nettoyer la machine ont été utilisés pour dresser un tableau quantitatif des avantages associés à la technique TG-CXR.

Résultats : Les technologues ont été formés à la méthode TG-CXR lors d'une séance d'information de 15 minutes au moment du changement de poste. Cela s'est traduit par un coût unique de 424,88 USD.

Keywords: Cost-benefit; Chest radiograph; Portable; COVID-19; Process-improvement

Introduction

The COVID-19 (Coronavirus disease 2019) pandemic has posed many unprecedented challenges to the healthcare system. Foremost amongst these is the challenge of safeguarding the health and safety of healthcare personnel in the face of worldwide shortages of personal protective equipment (PPE) [1–4]. Finding innovative ways to minimize frontline worker exposure and conserve PPE, while not sacrificing the quality of patient care, is therefore crucial in the global efforts to suppress this disease.

During the COVID-19 pandemic, the majority of hospital systems mandate that any patient presenting with symptoms potentially related to SARS CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) be treated as suspected COVID-19 infection or persons under investigation (PUI) until otherwise proven [5]. At our institution, these patients are screened at the entrance to the emergency department and then taken directly to respiratory isolation rooms.

While CT was primarily used as the first-line investigation of PUI in mainland China [6,7], this practice posed significant challenges from the perspective of infection control. As per ACR recommendations, CT decontamination procedures after scanning PUI may result in significant CT downtime, causing disruptions to essential radiological services. Therefore, the use of CT should be reserved for specific indications in the COVID-19/PUI patient population [8]. Chest radiography is a low-cost and widely used medical imaging tool that yields useful diagnostic information whether for initial evaluation or for follow-up of disease progression in patients presenting with respiratory complaints [9–14]. Due to its frequent utilization, improvement in techniques affecting the process of obtaining chest radiographs could make immediately noticeable impacts on both PPE stocks and hospital budgets. The Radiological Society of North America (RSNA) scientific expert review panel proposed an innovative method of obtaining portable or bedside chest radiograph through glass walls of isolation rooms on March 18, 2020 [15]. This technique was subsequently shown to be able to produce diagnostic quality radiographs with no significant increase in radiation to the patient [16–19]. With some refinements, our hospital quickly adopted this technique. However, in this chaotic time, many institutions around the

world are faced with conflicting priorities when initiating new procedures. There is a need for quantitative analysis of the cost and benefit of establishing the TG-CXR method to facilitate wide adoption of this technique. The purpose of this study is to evaluate and quantify the costs and benefits of adopting the TG-CXR technique.

Conclusion : L'adoption de la technique TG-CXR pendant la pandémie de COVID-19 a entraîné un coût ponctuel minime, mais devrait se traduire par un bénéfice net de plus de 51 000 USD par an dans notre service d'urgence.

world are faced with conflicting priorities when initiating new procedures. There is a need for quantitative analysis of the cost and benefit of establishing the TG-CXR method to facilitate wide adoption of this technique. The purpose of this study is to evaluate and quantify the costs and benefits of adopting the TG-CXR technique.

Materials and methods

Research and Ethics Board approval was not required for this quality improvement project.

Normally, a portable X-ray machine is operated by a team of two technologists [20]. The X-ray machine is brought into patient room where Technologist 1 positions the patient while Technologist 2 operates the machine. Both technologists are required to don a set of PPE prior to entering the room if there is a patient requiring droplet precautions, and both the x-ray machine and the cassette or detector require comprehensive cleaning using sanitary wipes upon exiting the room.

In comparison, the TG-CXR method involves having only Technologist 1 don PPE and enter the isolation room to position the patient and cassette/detector, while Technologist 2 stays with the portable x-ray machine outside of the isolation room. Once the patient is in a satisfactory position, Technologist 1 will provide breathing instructions to the patient, and then signal Technologist 2 to trigger the exposure. While Technologist 1 waits in the isolation room, Technologist 2 confirms that the acquired image is of satisfactory quality. As the portable radiography machine was never in the patient's room, it does not require cleaning. Only the cassette is cleaned and only one set of PPE is utilized instead of two.

The above described method of radiograph acquisition was tested on phantom models at our institution to ensure quality and viability. The imaging parameters were optimized and the technique became the standard of practice in the emergency department of our institution on 23rd March, 2020 in the COVID-19 infected and PUI population. An official document was created by the x-ray technologist operational leader and the radiologists. The document detailed the protocols for PPE utilization and sanitization for both the conventional portable radiograph method and the portable chest

Table 1
Price of common PPE.

	Price per Unit in USD
Nitrile Gloves	\$0.03
Level 2 Procedural Masks	\$1.09
Face shield	\$2.01
Disposable Isolation Gown	\$0.41
Total PPE cost per set	\$3.54

PPE = Personal Protective Equipment, USD = United States Dollar

radiograph through glass method. This document was disseminated to all X-ray technologists via institutional network. The TG-CXR technique was also demonstrated by the lead technologists during shift change briefings. The briefings last for up to fifteen minutes and is routine at our institution. The cost of implementation of TG-CXR was obtained from our department's operational database and calculated based on the number of technologists, the training time required, and the per hour average salary of technologists. Cross-sectional review of the hospital picture archiving and communication system (PACS) of studies identified TG-CXRs performed from March 23, 2020 to April 13, 2020.

To quantitatively assess the benefits of adopting the TG-CXR method, the prices of the routinely consumed PPE including gloves, surgical masks, isolation gowns, and face shields and sanitization material including disinfectant wipes, isopropyl alcohol and cotton swabs were obtained from the Procurement Office at our institute. The machine downtime and sanitization resources required for portable X-ray machine cleaning were measured by observation of technologists on three separate instances and mean values were calculated. From our department's operational database, the average salary (including benefits) of X-ray technologists at our institution (\$36.16 USD/h) was obtained. The hourly rate for two technologists were multiplied by times saved by reduction in the machine disinfection time/downtime to calculate the financial savings associated with TG-CXR method.

Results

There were a total of 316 chest radiographs obtained using the TG-CXR method during the study period— an average of 14.4 imaging studies each day. Given that we have a total of 47 x-ray technologists, the adoption of the TG-CXR technique involved a one-time training cost of \$424.88 USD (\$9.04 USD per technologist).

Table 2
Portable machine sanitization materials, time, and cost after PUI exposure.

	Trial 1	Trial 2	Trial 3	Average	Average Cost
Machine Downtime	4 min 29s	4 min 42sec	5 min 14s	4 min 48 s	\$5.79 USD
Sanitary Wipes Consumed (0.07 USD per wipe)	8	6	7	7	\$0.49 USD
Isopropyl Alcohol Consumed (mL) (\$1.31 USD per 500mL)	3	4	3.5	3.5	\$0.01 USD
Number of Cotton Swabs used (\$0.02 USD per swab)	2	2	2	2	\$0.04 USD
Total Cost of Machine Sanitation per Radiograph					\$6.33 USD

USD = United States Dollar

Adoption of the TG-CXR technique resulted in one less set of PPE used per imaging study performed. The total per unit cost of PPE was \$3.54 USD (detailed in Table 1).

The TG-CXR technique also minimizes the need for portable x-ray machine sanitization in between studies. This includes wiping the machine body with sanitization wipes and wiping the screen with a cotton swab soaked in isopropyl alcohol and allowing it to dry. The resultant average reduction of machine downtime of 4 min and 48 s per study which when multiplied by average salary of two X-ray technologists translate to financial benefit of \$5.79 USD per radiograph. The average cost of sanitization material consumed was \$0.54 USD (Table 2) per cleaning cycle.

Using the above data, the benefit of adopting the portable chest radiography through glass is \$9.87 USD per radiograph. Assuming a stable demand for chest radiographs on isolation patients, the projected health systems savings of adopting this technique in the emergency department of our institution is \$51,876.72 USD per year (Table 3) – translating to a net benefit of \$51,451.84 USD per annum when the one-time training cost is taken into account.

Discussion

Through quantitative analysis, we have demonstrated that the implementation of the TG-CXR technique at our emergency department of our hospital involved only a minimal one-time training cost. However, it did yield significant potential net cost saving of over \$51,000 USD per year.

Healthcare workers are a scarce resource and keeping them safe is critical to ensure that there is adequate staffing to provide patient care. The TG-CXR technique decreases the number of staff exposed to PUI/COVID positive patients which results in decreased risk of transmission which provides an important advantage during our fight against the current pandemic.

During the current pandemic, hospitals around the world have struggled to maintain adequate PPE supply, making PPE conservation effort critical to maintaining hospital function [1–4]. The TG-CXR technique uses 50% less PPE than the conventional technique, thereby conserving a valuable resource.

During cleaning, portable X-ray machines are exposed to chemical agents which may result in reduced functionality and increased downtime and maintenance costs. Sensitive surfaces such as the touch screens may be particularly vulnerable to the effects of cleaning agents [21]. Use of TG-CXR decreases the number of cleaning cycles the machines are subject to,

Table 3
Benefit per radiograph and future projected.

	Per radiograph	1 year	5 years
Dollar saving from PPE conservation	\$3.54 USD	\$18,606.24 USD	\$93,031.20 USD
Dollar savings from sanitization material	\$0.54 USD	\$2,838.24 USD	\$14,191.20 USD
Portable machine downtime reduction	4 min 48 sec	112 h 14 min 24 sec	561 h 12 min 00 sec
Reduction of technologist cost	\$5.79 USD	\$30,432.24 USD	\$152,161.20 USD
Net benefit	\$9.87 USD	\$51,876.72 USD	\$259,383.60 USD

PPE = Personal Protective Equipment, USD = United States Dollar

which may prolong their usable life and decrease maintenance costs.

A rational next step for expansion of utilization of this technique would be to include emergency patients who are not considered PUIs but are under isolation precautions for other reasons (e.g. bacterial meningitis, *C. Difficile*, tuberculosis) as well as immunocompromised patients requiring reverse isolation. In the future, the “through glass” technique may be expanded to include imaging studies other than chest radiography (such as abdomen and extremity imaging), yielding increased cost savings. The ease of implementation and cost savings associated with instituting the TG-CXR technique makes a strong argument for its continuation in the post-COVID-19 pandemic era. This technique can continue to provide significant savings as well as reduce healthcare professional exposure to patients isolated for other infectious illnesses requiring isolation precautions.

Our study is limited in that we have only used data from a single institution. The exact cost savings will vary by institution as the cost of PPE and technologist salaries do vary from region to region. Given that we provided comprehensive calculation to include all quantifiable aspects of cost-savings, the numerical result from our study can be seen as an achievable upper limit of the projected cost savings a hospital can expect after adapting TG-CXR. Another limitation of the study is the small sample size when recording machine downtime and cleaning supply usage. We also recognize that not all hospitals are built with glass partitions between patient rooms and staff areas and thus through glass technique may not be universally implementable. Leadership of those institutions may consider the benefits of through glass technique in planning the design of future patient care areas. Finally, although a shift change briefing is part of the routine workflow in our hospital, we have presented the one-time cost of implementation to assist other institutes who may have a different workflow. In the landscape of the current pandemic, there are additional benefits associated with adoption of the TG-CXR method that our study methodology could not quantify. These include potential decrease in sick leave, employee healthcare costs and psychological stress from decreased risk of transmission, as well as potential reduction in administrative time, effort and cost required to procure adequate PPE supplies.

In conclusion, adoption of the portable chest radiography through glass in our emergency department during the COVID-19 pandemic involved a small one-time cost of \$424.88 USD, but resulted in continued cost saving of \$9.87

USD per radiograph and a projected savings of \$51,876.72 USD per year (\$51,451.84 USD net savings). We hope that our findings would encourage policy-makers to implement TG-CXR technique at their institutions when and where possible.

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