ORIGINAL ARTICLE

Chest X-Ray As an Essential Part of Routine Medical Examination: Is It Necessary?

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SUMMARY

Introduction: Various studies in primary care and hospitalized patients have discouraged routine use of chest x-ray (CXR) in medical examination.

Purpose: The study aims to determine the prevalence of abnormal routine CXR and cost of one CXR at a public health clinic and discuss the rationale of CXR in routine medical examination.

Methodology: Data of patients who visited Klinik Kesihatan Bandar Kota Bharu (KKBKB), a public health clinic, from 1 January until 31 December 2010 were examined. The study used cross-sectional design. All patients who came for medical examination and CXR at KKBKB were included. Cost analysis was performed from the perspective of provider.

Findings: About 63.1% of 8315 CXR films in KKBKB were produced as part of routine medical examination. Prevalence of abnormal CXR was 0.25%. The cost of producing one CXR ranges from RM15.87 to RM32.34.

Discussion: Low yield from CXR screening and high cost of CXR are the main concern. CXR screening would also lead to unnecessary radiation; and false-positive screening resulting in physical risk, unwarranted anxiety and more expenditure. CXR screening is appropriately reserved for high-risk patients and those with relevant clinical findings.

KEY WORDS:
Chest x-ray, screening, cost analysis, routine medical examination

INTRODUCTION

Routine medical examinations are conducted for future employees, employers above 40 years old, new private and public college or university students prior to admission, individuals going to perform haj, antenatal mothers and others. In current practice, CXR is not done routinely for most of these groups but only when justified by medical history and physical examination. However, public health clinics with x-ray facilities are obliged to perform CXR for new employees or new students attending higher learning institution authorities in both public and private sectors.

Many hospital-based studies have scrutinized and discouraged routine use of CXR on in-patients[1,2]. Routine use of CXR examination in primary care has also been subjected to discussion regarding its utility in patient care and cost-effectiveness[3]. National guidelines on control of tuberculosis recommended that only high-risk groups be screened for tuberculosis (TB). These groups include contacts of sputum positive TB patients, persons with HIV infection, immigrants from countries with high TB prevalence, institutionalized persons such as prison inmates and patients with other medical risk factors such as diabetes mellitus, silicosis and immunosuppressive states[4]. In 1997, Health Technology Assessment Unit recommended that CXR should not be performed routinely but to be justified by history and clinical examination[5]. In a broader view, the usefulness of pre-employment medical screening has been questioned, as the use is often driven more by cultural practices than evidence[6]. Pre-employment health screening in NHS England involves only health questionnaires and interview with occupational health nurse. Referral to physician is made when appropriate[7]. While in some countries such as Netherlands and USA, pre-employment enquiries are only lawful if they relate to 'the ability of an applicant to perform job-related functions'[8,9].

This study aims to determine the prevalence of abnormal routine CXR, calculate the cost of one CXR at a public health clinic and discuss the rationale of current practice of screening healthy individuals with routine CXR.

MATERIALS AND METHODS

The study used a cross-sectional design and cost analysis from the perspective of the provider (Ministry of Health Malaysia). Data of patients who visited Klinik Kesihatan Bandar Kota Bharu (KKBKB), from 1 January until 31 December 2010 were examined. KKBKB is the largest government health clinic in Kelantan, a northern east state in the country. KKBKB received about 600 to 725 outpatient visits per day.

Sample size calculations for a single proportion were based on two-sided testing with an α of 0.05 and desired power of 80%. The minimum required sample size was 1357. We included all patients who came for medical examination and CXR at KKBKB within the study period as samples. CXR were considered routine when the purpose was for pre-employment or pre-admission to public or private higher learning institutions. Patients who had medical examination for the purpose of performing pilgrimage ('haj') or had been diagnosed with cardiac or thoracic diseases were excluded.

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Table I: List of cases with abnormal CXR findings

Cases	Age (years)	Gender	CXR findings
1	20	Female	Lung opacity
2	19	Female	Consolidation right mid zone
3	18	Female	Lung opacity
4	22	Male	Opacity left zone
5	40	Male	Lung opacity
6	38	Male	Right mid zone consolidation
7	25	Female	Abnormal fissure line
8	24	Male	Fibrotic upper lobe
9	18	Female	Cardiomegaly
10	18	Female	Cardiomegaly
11	25	Female	Thoracic scoliosis
12	24	Female	Thoracic scoliosis
13	21	Male	Thoracic scoliosis

Table II: Fixed and variable cost of one CXR at the KKBKB

	Cost items	*Cost per unit (RM)
A	**Fixed costs**	
1	X-ray machine Toshiba KXO-80G	0.40
2	X-ray view box	0.01
3	Chest stand	0.15
4	X-ray processor	0.10
5	ID camera	0.02
6	X-ray room*	3.48
7	X-ray room furniture	0.05
B	Variable costs	
1	Maintenance of x-ray unit	0.22
2	Staff emolument	4.63
3	Utilities (water, electricity, communication)	4.52
4	Administrative cost	0.62
5	X-ray film	1.67
	Total cost of one CXR	**15.87**

*Annuity factor for 5 years at a discount rate of 5%, AF5,5%=4.3295

Table III: CXR cost variations with different annuity factors and workload

Variables	Cost of one CXR (RM)
Annuity factor for 5 years at a discount rate of 5% $AF_{5,5\%}$= 4.3295	15.87
Annuity factor for 5 years at a discount rate of 10% $AF_{5,10\%}$= 3.7908	17.05
Annuity factor for 5 years at a discount rate of 0% $AF_{5,0\%}$ = 5.0	14.64
Annuity factor for 5 years at a discount rate of 5% $AF_{5,5\%}$= 4.3295, with 50% workload	32.34

Data were collected from electronic medical records retrieved from Advanced Clinic Management System (ACMS). Convenient sampling was used in which all samples that fulfilled the criteria were included in the study. Search terms were 'medical examination' and 'RME' (routine medical examination). We defined 'abnormal CXR' as CXR films that reported as having abnormal finding by medical officer in KKBKB. Study parameters were gender, age, race and CXR findings. Descriptive analysis of demographic data was conducted with Microsoft Excel.

Costing

Cost analysis is from the viewpoint of the provider (Ministry of Health Malaysia). All items involved in producing processed CXR films were listed and categorized as fixed and variable costs. Fixed costs included cost of x-ray room, x-ray machine, x-ray view box, chest stand, x-ray processor, ID camera and furniture. Variable costs were utilities, x-ray films, maintenance, salaries of staff and administrative cost. Unit cost was calculated for every cost item.

Market price was used in costing. The initial capital purchasing price of fixed assets were annuitize over their useful life that is 20 years for buildings and 5 years for clinical equipment[8]. The value of building was distributed according to space occupied by clinic activities and divided by the number of patients using them to obtain one unit cost. The cost of x-ray machine and other equipment were divided by number of patients using them (including other forms of x-ray) to produce one unit cost. Emolument cost was calculated only for clinic staffs involved in the activities. Salary scales were referred to salary of staff that had worked for five years[10]. The cost was allocated based their time spent in the process of producing one CXR. Annual salary was divided by 9600 to obtain emolument cost per minute. The working period was set at 20 days a month and 8 hours a day.

Future costs were discounted at 5%[11,12]. Sensitivity analysis was deployed to determine how changes in one variable(s) would affect the dependent variable (cost of one CXR). Variables used were 10% and 0% discount rates, and 50% workload.

RESULTS

A total of 9,420 x-rays films (all forms) were produced from January 1st until December 31st 2010 at KKBKB. About 88.3% (8315 films) were CXR films. Of these, 5246 CXR films (63.1%) were produced as part of routine medical examination. About 49.5% of sam-ples were male. The majority of the sample were Malays. Thirteen abnormal CXR were found in them (5 male and 8 female subjects). The prevalence of abnormal CXR is 0.25%. There were eight lung field anomalies and three cases reported as cardiomegaly, while the remain¬ing were three skeletal abnormalities. Table I shows the description of all abnor¬mal CXR.

Table II shows the contribution of each cost items for one CXR. Cost items are categorized into fixed and variable costs. KKBKB received a high number of about 600 to 725 patients a day in year 2010. Therefore, we also examined the effect of workload on cost as shown in Table III.

DISCUSSION

Low yield of abnormal CXR

The prevalence of abnormal CXR in KKBKB was 0.25%. By excluding skeletal abnormalities, the prevalence of abnormal CXR pertaining to respiratory or cardiac diseases was only 0.18%. The low yield is similar to other studies. Tigges *et al.* found that 1.12% of primary care patients had abnormal CXR finding when subjected for routine CXR examination[3]. In 1997, a similar study at Hospital Melaka showed that only 1.97% of patients had positive findings[5].

CXR screening is for high-risk patients

Most studies that studied the subject of CXR screening in high-risk patients were done in hospital settings. A randomized controlled trial showed that annual screening with chest radiograph does not reduce lung cancer mortality[13]. A prospective study on 10000 CXR examinations in a hospital-based population suggested that CXR should only be done whenever chest disease or a reasonable possibility of chest disease is suspected[14]. Sub-committee on Prescription of Exposure to X-rays (Environment Protection Agency 1976) recommended that CXR examinations should generally not be done merely for hospital admission on patients under the age of 40 unless a clinical indication of chest disease exists[15]. Humphrey et al echoed these findings in her study on patients admitted for vascular surgery[16]. She concluded that routine CXRs were not helpful in improving patient outcomes. In a systematic review, Joo et al reiterated that routine CXRs should not be performed for hospitalized patients without risk factors[17]. This evidence suggested that hospital patients without possibility of chest disease do not benefit from CXR. In general, hospital patients are unhealthier than the whole population. Therefore, the rationale of performing routine CXR on asymptomatic young patients remains unclear.

Patients for CXR are best identified by a careful history and physical examination (Tape *et al* 1986). CXR screening is appropriately reserved for high-risk patients such as old age and symptomatic patients. Studies found high prevalence of abnormal CXR in their studies involving elderly patients[18,19]. Screening for chest abnormality in veterans could produce more than 46% of abnormal findings[14]. Butcher *et al.* found that 34.8% of the 221 patients with a chief complaint of cough, dyspnea, or pleuritic chest pain have a high likelihood of having new clinically important abnormalities found on their chest radiographs[19].

The necessity of mandatory CXR in trauma patients had been questioned as it had a low yield for abnormal findings[20]. The study found that by relying on clinical judgment to the need of CXR would have eliminated 49.9% of unjustified CXR. Similarly, reliance on clinical acumen rather than routine should be the practice in primary care settings.

Harmful effects of screening and radiation

The effective radiation dose of one CXR is approximately 0.1 mSv that is equivalent to 10 days of exposure to natural background radiation. Therefore, the incidence cancer following CXR is said to be minimal, which is estimated at about one case for every 1000000 examinations[21]. However, Andrieu et al discovered that exposure to CXRs in carriers of BRCA1 and 2 genetic mutations were associated with an increased risk of breast cancer; particularly those exposed before the age of 20 years (HR=4.64; P<0.001)[22].

Radiation is not the only concern with CXR screening. False-positive screening results would lead to physical risk, unwarranted anxiety and more expenditure particularly due to further testing including invasive procedures[23,24]. Calculations based on estimates of the accuracy of chest radiographs and the likelihood of disease suggest that routine chest radiography may result in many more misleading than helpful results[1]. Tigges *et al* found that 14 out 15 cases (from 1282 samples) initially reported as major abnormality proved to be false positive[3]. In a multimodal cancer screening program, the cumulative risk of having at least one false-positive CXR result is about 9% or greater and 4% with false-positive CXR ended up with invasive procedures[25].

Given the low yield of abnormal findings, high false positives and possible harm from radiation exposure, a selective policy is deemed more appropriate on screening apparently healthy individuals with CXR. A selective policy would subject only individuals with clinical indications of chest diseases for routine medical CXR.

Costing

We found that the cost of producing a reported, single postero-anterior view CXR is RM15.87. The fixed cost is less than 30% of total cost but variable cost (in particular staff emoluments, x-ray films and utilities) contributed more than 70% of total CXR cost.

Reducing the workload (number of x-rays done) by 50% would increase the cost up to RM32.34. The is comparable to cost of reported, single view CXR in private medical centers in Kota Bharu town which is between RM35.00 and RM40.00. Health clinics with smaller number of patients than KKBKB would incur a much higher cost of producing CXR.

With more than 5000 routine CXR films produced in a year, the expenses would be substantial and yet the benefits are unclear. By applying a selective policy on screening with CXR, KKBKB could spend up to RM83,000 a year for other activities.

Limitations

The data were based on medical records. Information bias caused by improper documentation could affect the study findings. We were not able to determine the number and consequences of false-positive results because all individuals with positive findings were lost during follow-ups. Medical officers who interpret CXR films at health clinics could have reported false positive or negative findings. A full cost analysis study (cost-effectiveness or cost-benefit analysis) with prospective study design and a radiologist being part of the study team would be ideal.

This study employed provider's view on costs in order to illustrate cost incurred by Ministry of Health. Societal view would also include the cost borne by patients. For example, the time consumed to produce CXR is about 10 to 15 minutes; and this would be substantial when translated into cost. Cost of training is expensive but difficult to ascertain, therefore it was not calculated in this study.

CONCLUSION

Despite low prevalence of abnormal CXR and substantial annual cost incurred, the rationale of performing routine CXR as a screening tool in young individuals remains unclear.

RECOMMENDATIONS

We should be selective in performing routine pre-employment and pre-admission CXR because it affects the efficiency of health services in terms of cost and time. The potential impact of eliminating unnecessary routine CXRs is an estimated saving of up to RM83,000 annually in one public health clinic in district of Kota Bharu. Besides, unnecessary radiation and false positive screening results can be avoided.

CXR should not be routine in medical check up but instead focus on high-risk group of patients with relevant clinical findings. Doctors who perform routine medical examination must only request for CXR when clinically justified by patient's history and physical examination. A selective policy of CXR, which relies on indications generated by clinical acumen, would be beneficial to the patients, health staffs and primary health care system.

The aims of health screening and the tools used must be explicit, as it would also help to assess the effectiveness of health checks and its purpose. Perhaps it is timely to revise the current practice by considering the needs, current health situation, economics, ethical issues and legislations.

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