Frequency of abnormal findings on routine chest radiography before cardiac surgery

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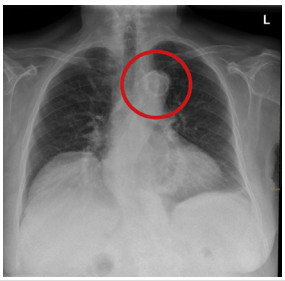
ABSTRACT

Objective: Preoperative chest radiograph screening is widely used before cardiac surgery. The objective of this study was to investigate the frequency of abnormal findings on a routine chest radiograph before cardiac surgery.

Methods: In this retrospective cohort study, 1136 patients were included. Patients were scheduled for cardiac surgery and underwent a preoperative chest radiograph. The primary outcome was the frequency of abnormalities on the chest radiograph. Secondary outcome was the effect of those abnormalities on surgery.

Results: One half of the patients (570/1136; 50%) had 1 or more abnormalities on the chest radiograph. Most frequent abnormalities were cardiomegaly, aortic elongation, signs of chronic obstructive pulmonary disease, vertebral fractures or height loss, possible pulmonary or mediastinal mass, pleural effusion, and atelectasis. In 2 patients (2/1136; 0.2%), the chest radiograph led to postponement of surgery, whereas in none of the patients the surgery was cancelled. In 1 patient (1/1136; 0.1%) the surgical approach was altered and in 15 patients (15/1136; 1.3%) further analysis was performed without having an impact on the planned surgical approach.

Conclusions: Although abnormalities are frequently found on preoperative chest radiographs before cardiac surgery, change in clinical management with regard to planned surgery or surgical approach occurs infrequently. (J Thorac Cardiovasc Surg 2018;155:2035-40)



Chest radiograph of an 81-year-old woman with extensive aortic calcifications.

Central Message

Abnormalities are frequently found on preoperative chest radiographs before cardiac surgery, but change in clinical management with regard to planned surgery or surgical approach occurs infrequently.

Perspective

A routine preoperative chest radiograph rarely has direct consequences for the planned surgery or surgical approach. Most abnormal findings are to be expected (eg, cardiomegaly) and therefore do not have a direct effect on the surgery. However, some findings can substantially alter the surgical approach in specific cases.

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More than 30 billion dollars is spent annually on preoperative testing in the United States.[1] A conventional chest radiograph is performed before both cardiac and noncardiac surgery in many hospitals as part of the routine workup. Although the cost of a chest radiograph is relatively low (estimated at $31[2]) and the associated radiation risks are small, there are doubts about the efficacy of routinely performing preoperative chest radiographs. For noncardiac surgery, several studies have demonstrated that a routine preoperative chest radiograph does not decrease morbidity or mortality.[3] The frequency of abnormal findings on a routine preoperative

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Abbreviations and Acronyms

COPD = chronic obstructive pulmonary disease
CT = computed tomography
LUS = lung ultrasound
UMCU = University Medical Center Utrecht

chest radiograph before noncardiac surgery is 10%, but in only 0.1% does this cause a modification of clinical management.[4] Therefore, it is recommended to only perform a preoperative chest radiograph if the results are expected to change perioperative management.[5] Despite these recommendations, routine chest radiographs are still performed frequently before noncardiac surgery.[6]

In cardiac surgery, however, the frequency of abnormal findings on routine preoperative chest radiography is unknown. Cardiac surgery guidelines do not give recommendations whether a routine chest radiograph should be performed before cardiac surgery.[7-10] Because cardiac surgery is associated with greater risks, routine chest radiography can possibly contribute to improved preoperative risk assessment.

To the best of our knowledge, there are no published studies that have investigated the frequency of abnormalities on routinely performed preoperative chest radiography in patients undergoing cardiac surgery. Therefore, the primary goal of this study was to investigate the frequency and types of abnormalities found on routinely performed chest radiographs in patients scheduled to undergo cardiac surgery. The secondary goal was to assess the effect of the preoperative chest radiograph on planned surgery.

METHODS

The STROBE (Strengthening The Reporting of OBservational studies in Epidemiology) guidelines for observational studies were used.[11] A retrospective cohort study was performed at the University Medical Center Utrecht (UMCU). The UMCU is a tertiary referral center and 1 of 16 hospitals in the Netherlands that performs cardiac surgery. The local institutional review board waived the need for informed consent (institutional review board approval: June 25, 2016; protocol number 15-359/C), because the study only involves retrospective analysis of recorded data.

Chest Radiography

A chest radiograph is part of the routine preoperative work-up at the UMCU. A chest radiograph in the lateral and posteroanterior direction was made with a digital flat-panel detector system with a tube potential of 125 kV (Philips Healthcare, Best, The Netherlands). The mAs value was optimized per patient by using automated exposure control. All radiographs were assessed and reported by a radiologist or radiology resident in the routine clinical care setting. No structured reporting was used. The reporting radiologist had access to previous imaging examinations as well as the electronic patient file.

Data Collection and Analysis

Patients from different hospitals are referred to the UMCU for cardiac surgery. After the patient is discussed in a multidisciplinary meeting and approved for surgery, the patient is invited to the hospital for preoperative screening. During this screening, the clinical history is obtained as well and a physical examination as well as preoperative tests, including a chest radiograph, are performed. A random selection of all chest radiographs ordered by the Department of Cardiothoracic Surgery between May 2011 and August 2015 was automatically extracted from the Picture Archiving and Communication System. The text-based chest radiograph reports were assessed by 1 observer (A.H.) with 3 years of experience in radiology. The reports were made in routine clinical care by a radiologist and/or radiology resident at the time of acquisition. The chest radiograph images were not reassessed by the study observer. Postoperative chest radiographs were excluded. Patients who underwent screening for thoracic surgery or minimally invasive procedures (eg, video-assisted thoracoscopic surgery, lobectomy, mediastinoscopy, implantable cardioverter–defibrillator replacement, and procedures involving solely removal of sternal wires) were excluded.

Subsequently, the report was assessed to see whether any abnormalities were described. Abnormalities were divided in the following categories: pulmonary or mediastinal mass, consolidation, pleural effusion, cardiomegaly (cardiothoracic ratio ≥50%), aortic elongation, aortic calcifications, signs of cardiac decompensation, vertebral fractures or height loss, atelectasis, signs of chronic obstructive pulmonary disease (COPD), or a diaphragmatic herniation. In case of uncertainty, the observer discussed the described abnormality with a board-certified chest radiologist with more than 10 years of experience in radiology (P.J.).

Also, the date of the most recent chest radiograph before the routine preoperative chest radiograph and/or chest computed tomography (CT) was recorded. Both non–contrast-enhanced and contrast-enhanced cardiac and chest CT examinations were included as well as positron emission tomography–CT examinations. If a previous imaging examination was mentioned in the referral letter without the exact date of the examination and the examination was not available in the Picture Archiving and Communication System, the date of the referral letter was used.

The electronic patient file of the cardiothoracic surgery department was used to determine whether the chest radiograph results impacted the planned surgery. This was categorized as postponement of surgery, cancellation of surgery, change in surgical approach, or further diagnostic testing and analysis was needed. A direction relation between the abnormality described on the chest radiograph and the effect on surgery had to be mentioned.

For each patient, baseline patient characteristics, type of surgery, and postoperative complications were derived from the nationwide complication registry of the Dutch Association for Thoracic Surgery. This registry is based on the complication registry from the Society of Thoracic Surgeons and is mandatory for each patient undergoing cardiac surgery in The Netherlands. Completeness and accuracy of the nationwide complication registry are excellent (99% of the data are complete).[12]

Analysis was performed with SPSS, version 20.0.0 (IBM Corp, Armonk, NY). Data are presented as mean ± SD unless otherwise stated. Frequencies are provided as count and percentage. Data are presented by the use of descriptive analysis.

RESULTS

Patient Selection and Baseline Characteristics

The chest radiograph reports of a total of 1293 patients were screened. Overall, 157 patients were excluded because they underwent either thoracic surgery (n = 119) or minimally invasive surgery (n = 38; implantable cardioverter–defibrillator replacements and procedures involving solely the removal of sternal wires). Ultimately, 1136 patients were included. Baseline patient characteristics are provided in Table 1. Mean age was 65 ± 13 years and 30% was female. Details regarding the surgical procedure are provided in Table 2. Most surgeries

TABLE 1. Baseline characteristics

Variable	Participants (n = 1136)
Age, y, mean ± SD	65 ± 13
Sex, female/male	345/791
EuroScore, mean ± SD	5.43 ± 5.48
Length, m, mean ± SD	1.73 ± 0.09
Weight, kg, mean ± SD	81 ± 16
BMI, kg/m^2, mean ± SD	27.1 ± 4.4
Medical history	% (n)
Hypertension	56.1% (637)
Diabetes	20.0% (227)
COPD	10.1% (115)
Poor mobility	1.7% (19)
CVA	5.7% (65)
Endocarditis	1.1% (12)
Angina pectoris	6.0% (67)
Recent myocardial infarction (<90 d)	13.1% (146)
Atrial fibrillation	14.1% (160)

SD, Standard deviation; *EuroScore*, European System for Cardiac Operative Risk Evaluation; *BMI*, body mass index; *COPD*, chronic obstructive pulmonary disease; *CVA*, cerebrovascular accident.

were elective (772/1136; 70.2%) or within the same hospitalization for cardiac symptoms (324/1136; 29.5%), whereas 0.4% (4/1136) concerned emergency surgery. Seven percent of patients (76/1136) underwent a reoperation. Isolated coronary artery bypass grafting (547/1136; 48.2%), isolated valve surgery (270/1136; 23.8%), and coronary artery bypass grafting combined with valve surgery (151/1136; 13.3%) were the most common types of surgery. Seven patients (7/1136; 0.6%) underwent preoperative screening including a chest radiograph but did not proceed to cardiac surgery. This was because the surgery was considered too high risk after screening (n = 3); the patient declined surgery, which was not related to the chest radiograph (n = 1); the patient died before surgery (n = 1); or because after further analysis it was decided the disease and symptoms were not severe enough to perform surgery (n = 2).

TABLE 2. Treatment characteristics

Variable	% (n)
Elective surgery	70.2% (772)
Within same hospitalization	29.5% (324)
Emergency surgery	0.4% (4)
Reoperation	6.8% (76)
Type of surgery	
Isolated CABG	48.2% (547)
Isolated valve surgery	23.8% (270)
Isolated aortic surgery	0.4% (5)
CABG combined with valve surgery	13.3% (151)
Double- or triple-valve surgery	3.2% (36)
Aortic surgery combined with CABG and/or valve surgery	3.8% (43)
Other*	7.4% (84)

CABG, Coronary artery bypass grafting. *Including 7 patients without surgery.

Abnormalities Found on Chest Radiography

Overall, 50% of the patients (570/1136) had an abnormality on chest radiography. The frequency of abnormalities was as follows: a possible pulmonary or mediastinal mass (42/1136; 3.7%), consolidation (19/1136; 1.7%), pleural effusion (42/1136; 3.7%), cardiomegaly (cardiothoracic ratio ≥50%, 336/1136; 29.6%), aortic elongation (114/1136; 10.0%), aortic calcifications (3/1136; 0.3%), signs of cardiac decompensation (15/1136; 1.3%), vertebral fractures or height loss (72/1126; 6.3%), atelectasis (31/1136; 2.7%), signs of COPD (90/1136; 7.9%), and sliding diaphragmatic herniation (12/1136; 1.1%).

In 2 patients (2/1136; 0.2%), the chest radiograph led to postponement of surgery; in none of the patients was the surgery cancelled. In 1 patient (1/1136; 0.1%) the surgical approach was altered and in 15 patients (15/1136; 1.3%) further diagnostic testing and analysis was performed without affecting surgery. Postponement of surgery was caused by a suspicion of pulmonary infection in 1 patient. This patient also presented with dyspnea and high levels of C-reactive protein; therefore, the postponement of surgery was not solely caused by the abnormal chest radiograph. The second patient received additional tests because of right-sided pleural effusion on the chest radiograph, for which a chest CT and thoracentesis was performed. In a different patient, the surgical approach was altered. This was caused by extensive calcifications in the ascending aorta in a patient scheduled for conventional aortic valve replacement (Figure 1). On preoperative transthoracic echocardiography, the calcifications in the ascending aorta were not discovered because image artifacts due to extensive aortic valve calcifications, and obesity of the patient hampered the assessment of the ascending aorta. Aortic cannulation and placement of an aortic crossclamp was not deemed possible in an area free of calcifications. This finding, combined with an impaired pulmonary function and decreased exercise tolerance, led to the decision to change the surgical approach to a transcatheter aortic valve implantation.

Further diagnostic testing and analysis was performed in 15 patients because of a mass (n = 8), consolidation (n = 3), pleural effusion (n = 1), abnormal aspect of hilum (n = 1), aortic calcifications (n = 1), or a streaky pulmonary aspect (n = 1). From the patients with a mass, 3 patients were referred to another hospital for further analysis, 1 patient received an additional chest radiograph, which showed no abnormalities, 3 patients underwent an additional chest CT, which showed no abnormalities, and 1 patient underwent an additional chest CT on which a pulmonary nodule was found, which required follow-up. In 2 patients

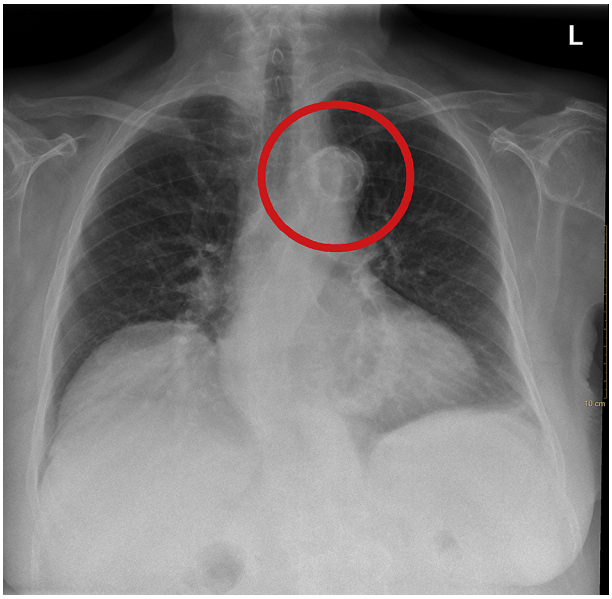

FIGURE 1. Chest radiograph of an 81-year-old woman in whom the surgical approach was altered due to extensive aortic calcifications (*red circle*).

with consolidation, an additional chest CT was made, which showed no abnormalities, whereas in 1 patient an additional chest radiograph was performed, which had no clinical consequences. The patient with pleural effusion was referred to the pulmonologist, who decided that the pleural effusion was most likely caused by cardiac decompensation. The patient with an abnormal aspect of the hilum received a chest CT, which showed no abnormalities. The patient with aortic calcifications received an intraoperative epiaortic ultrasound, which did not have consequences for the surgical strategy. The patient with a streaky pulmonary aspect was referred to a pulmonologist and received a follow-up chest radiograph, which showed plate atelectasis.

Previous Imaging

The routine preoperative chest radiograph was made 9 ± 11 days before surgery. Fifty-nine percent (669/1136) of patients had undergone an additional chest radiograph in the year before surgery, on average 58 ± 58 days before surgery. Twelve percent (138/1136) of patients underwent a cardiac, chest, and/or positron emission tomography–CT in the year before surgery. Most patients who underwent a preoperative CT also underwent additional chest radiographs; therefore, in total 63% (726/1136) of patients had a recent chest radiograph and/or CT at the moment they received the routine preoperative chest radiograph.

DISCUSSION

This retrospective study provides insight into the frequency of abnormal findings on routine preoperative chest radiography in patients scheduled to undergo cardiac surgery. Although the vast majority of abnormal findings did not have a direct effect on the surgery, the information provided by routine preoperative screening chest radiography can substantially alter the surgical approach in selected cases.

The frequency of abnormal findings on routine preoperative chest radiography has been investigated extensively in noncardiac surgery. A systematic review and a meta-analysis,[3,4] with considerably overlap in included studies, reported abnormal findings in 10% of the patients. Most common findings were associated with chronic disease, namely cardiomegaly and COPD, which is similar to the results in the current study. The frequency of abnormal findings in the current study was considerably greater. It is likely that some abnormalities are more common in patients undergoing cardiac surgery compared with noncardiac surgery, such as cardiomegaly and elongation of the aorta. Furthermore, most studies in noncardiac surgery were performed in the 1970s and 1980s, and advancements in chest radiography have improved the image quality, which might have led to an increase in the frequency of abnormal findings.[13] Also, the definition of ''abnormality'' varies between studies and was relatively broad in the current study.

Even though cardiac surgery guidelines give no recommendations on the use of routine preoperative chest radiography, the National Collaborating Centre for Acute Care in the United Kingdom advises to perform preoperative chest radiography in all patients undergoing cardiac surgery based on consensus.[14] The costs associated with preoperative chest radiography are low, and if a preoperative chest radiograph could prevent 1 unnecessary surgery or prolonged hospitalization annually, those costs are easily compensated. Cost-effectiveness was not studied in the current study, but we showed that the frequency of abnormal findings is high. Although most abnormalities did not have an immediate impact on the surgery, in 2 cases the surgery was postponed and in 1 case the surgical approach was altered, whereas in 15 patients further diagnostic testing and analysis was performed without affecting surgery.

A preoperative chest radiograph could also serve as a comparison for postoperative chest radiographs. However, in the current study most patients had recent previous imaging available, which could also serve as comparison for postoperative chest radiographs. A preoperative chest radiograph might also be important for anesthesia management. In a large prospective multicenter study in 6111 patients, preoperative chest radiography altered anesthesia management in 0.2% to 3.5% of cases.[15] It was however unclear whether this changed management independent of clinical history and physical examination. Preoperative chest radiography also contributes to identifying patients with severe COPD or pleural effusion, which can be important for postoperative ventilator

management or intraoperative drainage of pleural effusions. However, also for this indication, the independent value of chest radiography is unclear, because it is also possible to assess severe COPD and pleural effusion with clinical history and physical examination.

There are several alternatives for chest radiography. First, lung ultrasound (LUS) can detect pulmonary abnormalities such as pleural effusion, pneumothorax, and lung consolidations.[16] The main advantage of LUS is the lack of ionizing radiation. Therefore, LUS is especially attractive in pediatric cardiac surgery.[17] However, current guidelines do not recommend the use of LUS for preoperative imaging.[18,19]

Another alternative would be to replace the preoperative chest radiograph by a preoperative chest CT. This offers the opportunity to improve visualization of pulmonary abnormalities and aortic atherosclerosis. The presence of atherosclerotic disease in the ascending aorta is associated with a 5-fold increased risk of postoperative stroke,[20] which is possibly caused by manipulation of the aorta during surgery causing embolization of atherothrombotic material. A recent review showed that a preoperative CT results in a change in surgical approach leading to decreased postoperative mortality and stroke in up to 17% of patients undergoing primary surgery.[21] The most common changes in the surgical approach were off-pump surgery instead of on-pump surgery and the use of a different cannulation site. Furthermore, the sensitivity of a chest CT for pulmonary nodules is high compared with a chest radiograph.[22] Finally, CT findings of for example emphysema may be able to more accurately predict problems in the intensive care unit postoperatively. Evidence for a routine preoperative CT is still weak, although an ongoing randomized clinical trial might provide more insight.[23,24] CT is more expensive compared with routine chest radiography. These additional costs can potentially be compensated by cost savings due to improved patient outcomes. Goldstein and colleagues[25] investigated the cost-effectiveness of a routine CT angiography before redo cardiac surgery and reported that patients with a preoperative CT angiography had improved perioperative outcomes while the total hospital charges remained the same. The cost-effectiveness of a preoperative CT, however, remains to be established in primary surgery and is one of the secondary outcomes of the previously mentioned ongoing clinical trial.[23,24]

The current study has several limitations. First, it concerns a retrospective study. However, to the best of our knowledge, this is the first study investigating the frequency of abnormal findings on routine preoperative chest radiography in a population undergoing cardiac surgery. Second, we used the routine clinical care chest radiograph reports that were not reported in a structured format. Therefore, information provided in the (unstructured) report was dependent on the reporting radiologist, although this does reflect routine care. Also, the radiologist did have access to previous imaging. Third, the effect of a preoperative chest radiograph on anesthesia management was not studied. Fourth, because of the retrospective design of this study, it is possible that patients in whom the surgery was delayed or changed were missed due to inaccurate reporting. Also, changes in the routine surgical approach based on the chest radiograph, such as choosing a different (peripheral) cannulation site in resternotomy patients, might have been missed. This may have resulted in an underestimation of the number of patients in whom the chest radiograph affected surgery.

In conclusion, this study shows that the incidence of abnormal findings on routine preoperative chest radiography in cardiac surgery is considerably greater compared with noncardiac surgery. Although most abnormal findings were to be expected (eg, cardiomegaly) and did not have a direct effect on the surgery, some findings can substantially alter the surgical approach in some cases.

Conflict of Interest Statement

Authors have nothing to disclose with regard to commercial support.

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Key Words: cardiac surgery, chest radiograph, chest x-ray, preoperative imaging, aortic calcification