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ORIGINAL ARTICLE

Routinely obtained chest X-rays after elective video-assisted thoracoscopic surgery can be omitted in most patients; a retrospective, observational study

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Abstract
Objective To investigate whether the use of routinely obtained chest X-rays is necessary after elective VATS.
Methods We retrospectively reviewed 1097 chest X-rays obtained routinely after elective VATS, performed in patients aged over 15 years during an 18-month period. VATS procedures were divided into three groups according to the degree of pulmonary resection. The chest X-rays (obtained anterior–posterior in one plane with the patient in the supine position) were categorized as abnormal if showing pneumothorax >5 cm, possible intra-thoracic bleeding and/or a displaced chest tube. Medical charts were reviewed for all patients with abnormal chest X-rays to see if an intervention was made based on the X-ray. In case of an intervention, detailed clinical data were collected.
Results 44 of 1097 chest X-rays (4.0 %) were abnormal and 10 of these X-rays (0.9 %) led to a clinical intervention. Proportions of abnormal chest X-rays were unequally distributed between groups ($p < 0.001$), whereas the number of interventions was not ($p = 0.43$). Of the ten chests X-rays that led to an intervention, three showed possible intra-thoracic bleeding, six showed pneumothorax >5 cm and one showed a kinked chest tube. All the patients with possible intra-thoracic bleeding were re-explored in the operating theatre the same day.
Conclusions Only 10 of 1097 chest X-rays (0.9 %) obtained routinely after elective VATS procedures led to a clinical intervention, supporting the abandon of routine chest X rays in favour of a more individualised approach, based on clinical observations.

Keywords Chest X-ray · Fast track · Video-assisted thoracic surgery

Introduction

By optimising individual components of perioperative care, the fast-track methodology has proven useful in reducing morbidity and mortality in thoracic surgery [1–4] and although omission of routine chest X-rays has been reported after fast-track video-assisted thoracic surgery (VATS) [1], no detailed data exist on the consequences of either obtaining or omitting these chest X-rays. In our institution, it is the standard procedure to obtain a chest X-ray in the post-operative care unit (PACU) after thoracic surgery and one-lung ventilation, as it serves to ensure satisfactory reflation of the lung, to check for signs of intra-thoracic bleeding and to visualise if the chest tube is correctly placed. However, as portable X-ray equipment is used, this practice is time-consuming and expensive, and it may expose other patients and personnel to ionising radiation.

With the objective of investigating whether routine use of chest X-ray in the PACU is necessary after elective VATS, we performed a retrospective study including chest X-rays from 1097 consecutive VATS procedures performed on patients older than 14 years during an 18-month period. Here, we report the incidence of abnormal chest X-rays as well as the proportion of these that led to a clinical intervention.

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Subjects

We included data from all patients aged ≥15 years undergoing an elective VATS procedure in our institution between January 1, 2012 and June 30, 2013, giving a total of 1099 procedures in 1004 patients. Two patients (undergoing one VATS procedure each) were excluded, as no chest X-ray was obtained on the day of surgery, leaving 1097 chest X-rays in 1002 patients for data analysing.

Methods

According to Danish law, this retrospective study was considered a quality assurance process which does not need approval by The Regional Ethics Committee. Collection and storage of data were approved by the Danish Data Protection Agency (Capital region, Denmark, Journal number 30-1098).

From all VATS procedures, data on age and gender of the patient, type of procedure, duration of surgery and time from end of surgery to obtainment of the chest X-ray were collected. Procedures were divided into three groups; a "no resection group" (pleural biopsy, placement of VATS guided myocardial pacemaker electrodes, mediastinal procedures, mechanical pleurodesis and evacuation of recurrent pleural effusion), a "minor resection group" (pulmonary biopsy, wedge resection and resection of pulmonary cysts) and a "major resection group" (lobectomy, bi-lobectomy and pneumonectomy).

The initial postoperative chest X-ray and its description by a radiologist was retrieved from a digital picture storage system, and reviewed by one of two of the authors (KJ and LSB). All chest X-rays were assessed according to a list of pre-defined criteria, based on the clinical experiences among the authors (Table 1). A chest X-ray was categorized as abnormal if meeting one or more of these criteria. In all cases with an abnormal chest X-ray, we reviewed the patient's hospital record, including registrations from the PACU, and registered any intervention made as a consequence of the X-ray. We defined a relevant clinical intervention as; repositioning of the chest tube, placement of an additional chest tube, applying/increasing chest tube suction, initiation of "pulmonary recruitment" [continuous positive airway pressure (CPAP) or positive expiratory end pressure (PEEP) treatments], administration of blood products or antifibrinolytic agents, prolonged observation in the PACU, transfer to the intensive care unit (ICU), or acute re-operation. For patients with an abnormal chest X-ray, all postoperative complications (before discharge) were registered and in case of a clinical intervention, detailed data from the PACU were collected on blood pressure, heart rate, haemoglobin concentration, arterial oxygen saturation, respiration frequency, body temperature, chest tube airflow and volume and appearance of chest tube output.

In case of discrepancy between the re-evaluation of a chest X-ray and the radiologist's report, the chest X-ray was discussed by all authors in plenum. This was also the case for chest X-rays causing doubt when first reviewed and all abnormal chest X-rays that resulted in an intervention. When interpreting these X-rays and their descriptions, documented intraoperative observations and preoperative X-rays were taken into consideration.

Table 1 Criteria used for assessing chest X-rays obtained in the post anaesthesia care unit after elective video-assisted thoracoscopic surgery

Pneumothorax ≥5 cm
Atelectasis involving a whole lobe or more
Blurring of the pulmonary field
Obliteration of the phrenic costal angle
Side hole(s) of the chest tube outside the thoracic cavity
Visible breaks or blocking in the length of the chest tube

Any chest X-ray fulfilling one or more of these criteria was categorized as abnormal

Outcomes

Our primary outcome was the incidence of abnormal chest X-rays resulting in a clinical intervention. Secondary outcomes were time from end of surgery to obtainment of the first chest X-ray, the overall incidence of abnormal chest X-rays, changes in clinical management and the frequency of postoperative complications in patients with an abnormal postoperative chest X-ray. From all patients with an abnormal chest X-ray resulting in a clinical intervention, we report relevant clinical observations from the intraoperative period and form the PACU stay (Table 2).

Surgery, anaesthesia and postoperative care

All procedures were performed using VATS techniques which have previously been described in details [5, 6] and all patients had general intravenous anaesthesia performed by an experienced anaesthesiologist with sub-specialisation in cardiothoracic anaesthesia. A left-sided, double lumen endotracheal tube was used for intubation.

At the end of one-lung ventilation, reflation of the lung was visualised by the surgeon through the thoracoscope and prior to extubation, bronchial secretion was removed by suction through the endotracheal tube. All patients were extubated in the operating theatre and then transferred to the PACU, where a chest X-ray was requested from the

Table 2 Detailed qualitative data on 10 patients receiving an intervention as a consequence of the chest X-ray obtained in the post anaesthesia care unit after elective video-assisted thoracoscopic surgery

	Preoperative data [age/sex, diagnosis, comorbidity, FEV1 (%)]	Surgery (side, procedure)	Intraoperative data [length of surgery (min)/ blood loss (ml)]	Abnormal data from PACU	Time from surgery to X-ray (min)	Abnormality on X-ray	Intervention	Postoperative complications/day of hospital discharge (POD)
1	16 yr/M, spontaneous pneumothorax, none, N/A	Right, resection of cysts + pleurodesis (Minor resection)	39/<50	–	75	Chest tube kinked at the level of the skin	Straitening of the chest tube	None/2
2	64 yr/M, suspected pleural malignancy, HA, 72	Left, pleural biopsy (No resection)	35/N/A	Airflow: none	85	Large apical/lateral pneumothorax	Initiation of PEEP therapy	SCE/5
3	82 yr/F, suspected pleural malignancy, none, N/A	Left, pleural biopsy (No resection)	86/N/A	Airflow: "a lot"	69	Large pneumothorax	Chest tube suction (-10 cm H_2O)	Air leak >7 days/14
4	53 yr/F, suspected pulmonic metastasis, previously right-sided costae-resection, 91	Right, wedge resection (Minor resection)	105/600	MAP $\approx$ 50 mm Hg chest tube output: 150 ml/H (bloody)	74	Blurring of right-sided pulmonary field	Prolonged stay in PACU. 1 g tranexamic acid	Intra-thoracic bleeding (re-operated twice)/5
5	71 yr/F, AC, HA, bronchial, previously right-sided lobectomy, asthma, 69	Right, wedge resection (Minor resection)	80/200	RF: 28, SAT: 92 % (+5l oxygen), chest tube output: 140 ml/H (bloody)	45	Slightly blurred right-sided pulmonary field. (Considered normal when seen in the PACU)	Repeated chest X-ray. (Because of bleeding in chest tube)	Intra-thoracic bleeding (re-operated POD0), progressing pneumothorax, empyema, cardiac arrest POD 33/71
6	65 yr/F, suspected pulmonic malignancy, HA, RA, oesophageal cancer, 97.6	Left, wedge resection (Minor resection)	29/650	RF: 23, HR: 110, output: 250 ml/H (bloody), airflow: none	135	Blurring of left-sided pulmonary field	Re-operation	None/3
7	76 yr/F, AC, none, 82.6	Right, lobectomy (Major resection)	84/50	–	77	Large apical pneumothorax	Chest tube suction (-15 cm H_2O)	Progressing pneumothorax/7
8	69 yr/M, NSCC, none, 65.7	Right, bi-lobectomy (Major resection)	177/100	Airflow: up to 3000 ml/min	108	Large lateral pneumothorax	Chest tube suction (-20 cm H_2O)	Air leak >7 days, infection (unknown focus)/18
9	75 yr/M, AC, HC, moderate alcohol abuse, 74.3	Left, lobectomy (Major resection)	116/<50	Airflow: up to 1000 ml/min after repositioning in bed	104	Large apical/lateral pneumothorax	Prolonged stay in PACU. Repeated chest X-ray	Air leak >7 days, diarrhoea, infection (unknown focus)/ 11
10	52 yr/M, AC, HIV positive, 84	Right, lobectomy (Major resection)	157/50	–	37	Large apical pneumothorax and atelectasis of middle lobe	PEEP therapy. Repeated chest X-ray	Recurrent atelectasis/11

AC adenocarcinoma, *F* female, *FEV1* forced expiratory volume in 1 s, *HC* hypercholesterolemia, *HA* hypertonia arterialis, *HIV* human immunodeficiency virus, *HR* heart rate, *M* male, *MAP* mean arterial pressure, *N/A* not available, *NSCC* non-small cell carcinoma, *PACU* post anaesthesia care unit, *POD* postoperative day, *RA* rheumatoid arthritis, *RF* respiratory frequency, *SAT* arterial oxygen saturation, *SCE* subcutaneous emphysema, *PEEP* positive expiratory end pressure, *Yr* years

radiological department upon arrival. The chest X-rays were obtained anterior–posterior in one plane with the patient in the supine position, using portable X-ray equipment, and the pictures were seen of either a thoracic surgeon or an anaesthesiologist on a standard computer monitor.

In the PACU, all patients were mobilised to standing position within few hours from arrival and standard monitoring included continuous pulse oxymetry, 3-leaded ECG, blood pressure monitoring (intermittent non-invasive or continuously intra-arterial depending on the type of procedure), and intermittent assessment of respiratory frequency, pain intensity, chest tube airflow and chest tube output. Patients who had undergone procedures with no or minor pulmonary resection, were discharged to the ward according to the guidelines recommended by the Danish Association for Anaesthesiology and intensive care medicine (http://www.dasaim.dk/, Accessed 14th of January 2015), whereas patients who had undergone major anatomical pulmonary resections remained in the PACU for an overnight stay.

Data analysis

Continuous data are presented as medians with interquartile ranges as none of the data showed normal distribution on histograms or probability plots. Categorical data are presented as numbers and group percentages, and compared between groups using the fisher's exact test. Data analysis was performed using IBM SPSS statistics version 20 (IBM, NY, USA), and $p < 0.05$ was considered significant.

Results

Data on age, gender, duration of surgery and time from surgery to obtainment of the chest X-ray are given in Table 3. The initial chest X-ray was obtained within 2.5 h from end of surgery in 95 % of the procedures and within 3 h in more than 98 % of the procedures.

Forty-four chest X-rays (4.0 %) from 44 patients, were abnormal according to our pre-defined criteria, and in ten patients (0.9 %), the abnormal chest X-ray led to a clinical intervention (Table 4). Proportions of abnormal chest X-rays were unequally distributed between procedures ($p < 0.001$), but the proportions of X-rays that led to an intervention did not differ significantly between groups ($p = 0.43$) (Table 4). Qualitative data on the ten patients who received an intervention as a result of an abnormal chest X-ray are given in Table 2.

34 patients had an abnormal chest X-ray that did not lead to an intervention (Table 4); 24 of these patients were discharged without encountering any postoperative complications whereas nine experienced complications in form of infection, atrial fibrillation, prolonged air leak (>7 days), recurrent pneumothorax and/or persistent pulmonary atelectasis. Finally, one patient was re-operated by VATS the same day, but the decision to re-operate was based on clinical observations and not a consequence of the postoperative chest X-ray. This patient is discussed in more details below.

Discussion

In this large-scale, retrospective study, we found that 44 of 1097 chest X-rays obtained directly after elective VATS were abnormal and that only 10 of these X-rays resulted in a clinical intervention (Table 4). Of the 10 patients who received a clinical intervention, three were re-operated; whereas, the remaining seven received less acute interventions such as increased chest tube suction, prolonged PACU stay or straightening of the chest tube (Table 2). Furthermore, only one of the three re-operations was performed as a direct consequence of the X-ray, whereas the other two were performed several hours later based on clinical observations and a repeated chest X-ray, respectively (Table 2). We believe that these findings are questioning the diagnostic value of obtaining a chest X-ray routinely after elective VATS. The proportion of abnormal chest X-rays in the no resection group was considerably higher than in the two other groups, whereas the proportions of interventions were alike in all groups (Table 4). These findings may reflect that interpretation of the chest X-rays was harder in the no-resection group, as it included patients with pleural carcinomatosis and recurrent pleural effusions possibly resulting in a higher frequency of pleural fibrosis and hereby decreased X-ray transparency.

The fast-track methodology is a multimodal approach, aiming at reducing perioperative morbidity and mortality, and reducing length of stay (LOS) [7, 8]. Throughout the last decades, the fast-track methodology has been implemented in both thoracotomy and VATS, among other things with the purpose of cost containment [1, 3, 9], and even though the use of routine chest X-ray in the PACU may not directly prolong LOS after elective VATS, it is still time-consuming and cost full, as well as it may expose other patients and personnel to ionising radiation.

The relevance of obtaining a chest X-ray routinely after minor procedures such as thoracocentesis and tracheostomy has been debated in the literature [10–12], whereas reports of either using or omitting routine chest X-rays in thoracic surgery is far more limited. We have not been able to find any data specifically addressing the use of routine

Table 3 Age and gender, duration of surgery and time from end of surgery to obtainment of the chest X-ray after 1097 procedures of elective video-assisted thoracoscopic surgery

	No resection $n = 134$	Minor resection $n = 619$	Major resection $n = 344$	Total $n = 1097$
Age (years)[a]	65 (50–72)	65 (48–72)	68 (62–74)	66 (55–72)
Gender[b]				
Male	87 (64.9)	351 (56.7)	151 (43.9)	589 (53.7)
Female	47 (35.1)	268 (43.3)	193 (56.1)	508 (46.3)
Duration of surgery (minutes)[a]	56 (41–92)	46 (34–64)	109 (90–135)	63 (41–101)
Time from end of surgery to chest X-ray (minutes)[a]	77 (58–96)	75 (55–94)	73 (54–97)	74 (55–95)

[a] Median (interquartile range)

[b] Number of patients (group percentage)

Table 4 Number of abnormal chest X-rays and number of abnormal chest X-rays leading to clinical intervention, in 1097 elective procedures of video-assisted thoracoscopic surgery

	No resection $n = 134$	Minor resection $n = 619$	Major resection $n = 344$	Total $n = 1097$
Abnormal chest X-rays*	16 (11.9)	13 (2.1)	15 (4.3)	44 (4.0)
Pneumothorax >5 cm	5 (3.7)	4 (0.6)	7 (2.0)	16 (1.5)
Possible intra thoracic bleeding	6 (4.5)	7 (1.1)	6 (1.7)	19 (1.7)
Chest tube displaced	8 (6.0)	2 (0.3)	3 (0.9)	13 (1.2)
Abnormal chest X-rays not leading to intervention[#]	14 (10.4)	9 (1.5)	11 (3.2)	34 (3.1)
Abnormal chest X-rays leading to intervention[#]	2 (1.5)	4 (0.6)	4 (1.2)	10 (0.9)

All data are given as number of patients (group percentage)

Comparison between groups (Fishers Exact test): * $p < 0.001$, [#] $p = 0.43$ [Abnormal chest X-rays; intervention vs. no intervention]

chest X-rays after VATS, but we believe that it is still common practice to obtain a chest X-ray routinely in the PACU after elective VATS, as we do it in our institution and as it were reported by Göettgens et al. [13]. In 2007, McKenna et al. reported the abandon of routine chest X-rays in fast-track VATS pulmonary resections, but their study did not specifically assess the consequences of this part of the protocol [1].

In a prospective study from 1997, patient management was directly affected by the assessment of a postoperative chest X-ray in 4 of 100 patients (4 %) admitted to the PACU after various surgical procedures [14] and another prospective study of 74 patients undergoing non-cardiac thoracic surgery (including 28 VATS procedures) found, that only 3 of 66 (5 %) postoperative chest X-ray led to a change in patient management, whereas no chest X-ray was obtained in the remaining eight patients [15]. Both of these studies conclude that obtainment of postoperative chest X-ray may not be necessary as routine in all patients, and that these chest X-rays should rather be based on clinical indications [14, 15]—conclusions that are fully in accordance with the findings of our study.

Obviously, it is necessary to obtain a postoperative chest X-rays in more than just a few per cent of the patients, but not necessarily in all patients. Instead, we suggest the use of clinical criteria's to identify patients where a chest X-ray would be relevant and in Table 5, we present a list of clinical observations which we would find relevant in defining such criteria's. However, it is emphasised that the list in Table 5 are based solely on the clinical experience of the authors and should not be taken for evidence-based recommendations.

Another relevant question is when to obtain a chest X-ray in the postoperative period; in our institution, the X-ray is obtained as soon as possible after arrival in the PACU, meaning that 95 % of the patients had their first chest X-ray within 2.5 h from end of surgery (Table 3). Maybe this is too soon? If a postoperative complication is not yet causing clinical symptoms, it may not yet be radiological evident either. An example could be the patient described in the results section, who were re-operated because of large, bloody chest tube outputs. His chest X-ray was obtained 65 min after surgery and was interpreted as normal by the anaesthesiologist on duty (In this study, the X-ray was categorized as abnormal because of a chest tube side hole placed outside the thoracic cavity). The patient was haemodynamic stabile throughout most of his stay in the PACU, but dropped in mean arterial pressure from 105 to 80 mmHg during the last hour.

Table 5 Author's suggestion for relevant clinical observations to consider when defining criteria's for when to obtain a chest X-ray in the post anaesthesia care unit after elective video-assisted thoracoscopic surgery

Intraoperative observations
Severe pleural adherences
Accidental tear of pulmonary tissue
Large bleeding (>500 ml)
Large volumes of bronchial secretions
Postoperative observations
Tachypnoea (RF >20/min)
Tachycardia (HR >100/min)
Hypoxemia, despite +3l. Oxygen (SAT <95 %)
Persistent hypotension (MAP <60 mmHg)
None or a large airflow in chest tube (>1000 ml/H)
Large bloody output in chest tube (100 ml/H)
Subcutaneous emphysema outside the operated hemi thorax

FEV1 forced expiratory volume in 1 s, *RF* respiratory frequency, *HR* heart rate, *SAT* arterial oxygen saturation, *MAP* mean arterial pressure

He was re-operated as he had bloody chest tube outputs of approximately 200 ml/h. We believe, that this example supports the use of clinically observations to decide not only in whom, but also when to obtain a chest X-ray.

Besides serving as postoperative control, a chest X-ray may also serve as reference in case of subsequent complications such as pneumonia, atelectasis, etc. However, does this justify obtainment of a postoperative chest X-rays in all patients? To answer this question, one should—among other things—consider the incidence of the postoperative complications in question, the potential diagnostic benefit of such "reference X-rays", and whether for example, a recent pre-operative X-ray would serve the same purpose. Another reason for obtaining a chest X-ray could be to identify a kinking or a suboptimal positioned chest tube, since clinical symptoms cannot accurately reveal these conditions, but is it relevance to identify such conditions if the chest tube sufficiently drains air and liquids, keeping the patient symptom-free?

This study has limitations. First, the definitions used for categorizing chest X-rays as "abnormal" were not evidence based, but pragmatically chosen based on clinical experience among the authors. Second, one of two authors (LSB and KJ) reviewed all the X-rays with the risk of inter-observant discrepancy. However, in all cases, the written description by a radiologist was included in the interpretation of the chest X-ray. Third, the accuracy of data from the PACU was limited by their retrieval from documents whit manually registration. Finally, as this is a retrospective, uncontrolled study, our findings should be considered hypothesis generating for future studies in the field of routine use of chest X-rays in elective thoracic surgery.

Conclusion

In reviewing 1097 chest X-rays obtained routinely after elective VATS, we found that 44 (4.0 %) were abnormal and that only 10 (0.9 %) led to a clinical intervention. These findings supports the abandon of routinely obtained chest X-rays after elective VATS in favour of a more individualised approach, based on clinical observations. However, due to methodological limitations our findings should be considered hypothesis generating necessitating further investigations in prospective, controlled settings.

Conflict of interest Lars S. Bjerregaard and Katrine Jensen declare no conflicts of interest. René Horsleben Petersen is speaker for Covidien, Takeda and Medela. Henrik Jessen Hansen is speaker for Covidien.

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