ORIGINAL ARTICLE

The low therapeutic efficacy of postoperative chest radiographs for surgical intensive care unit patients

A. KRÖNER [1, 2], E. VAN IPEREN [1], J. HORN [1], J. M. BINNEKADE [1], P. E. SPRONK [3], J. STOKER [4], M. J. SCHULTZ [1, 5, 6]

[1]Department of Intensive Care Medicine, Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands; [2]Department of Anesthesiology, Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands; [3]Department of Intensive Care Medicine, Gelre Hospital, Location Lukas, Apeldoorn, the Netherlands; [4]Department of Radiology, Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands; [5]Laboratory of Experimental Intensive Care and Anesthesiology (L·E·I·C·A), Academic Medical Center, University of Amsterdam, Amsterdam, the Netherlands; [6]HERMES Critical Care Group, Amsterdam, the Netherlands

ABSTRACT

Background. The clinical value of postoperative chest radiographs (CXRs) for surgical intensive care unit (ICU) patients is largely unknown. In the present study, we determined the diagnostic and therapeutic efficacy of postoperative CXRs for different surgical subgroups and related their efficacy to the time after ICU admission.

Methods. A prospective, observational study of consecutive postoperative surgical ICU patients was performed during a 10 month period. We restricted our analysis to CXRs obtained within six hours after admission to the ICU. Diagnostic efficacy was defined by the presence of predefined major abnormalities; therapeutic efficacy was defined by predefined actions taken because of any abnormality found on postoperative CXRs.

Results. Of 857 surgical ICU patients, 670 (78%) had a postoperative CXR after admission to the ICU. Of these CXRs, 80 were performed for clinical reasons, and 590 were routinely obtained (***i.e.***, these CXRs were made without a reason other than admission to the ICU itself). The diagnostic efficacy of clinically indicated and routinely obtained CXRs was 18% (14/80) and 13% (79/590), respectively. Of all predefined abnormalities found on CXRs, 60% involved the malposition of invasive devices, such as endotracheal tubes or central venous lines. The therapeutic efficacy of clinically indicated and routinely obtained CXRs was 4% (3/80) and 4% (26/590), respectively. While the diagnostic and therapeutic efficacy of routinely obtained CXRs were not dependent on timing of admission, the diagnostic and therapeutic efficacy of clinically indicated CXRs was higher for CXRs taken closer to the time of ICU admission.

Conclusion. Although the diagnostic efficacy of clinically indicated and routinely obtained postoperative CXRs in surgical ICU patients appears to be significant, their therapeutic efficacy is low. *(Minerva Anestesiol 2011;77:147-53)*

Key words: Radiography, thoracic - Intensive care units - Postoperative period.

Chest radiographs (CXRs) are commonly obtained for patients soon after intensive care unit (ICU) admission following major thoracic or abdominal surgical procedures. These postoperative CXRs are performed to determine whether thoracic abnormalities are present or absent and to evaluate the position of invasive devices, such as endotracheal tubes,[1, 2] central venous lines [3, 4] and/or surgical drains.[5, 6] However, most radiographic abnormalities found on postoperative CXRs,[7] like those found on routinely obtained CXRs,[8-11] resolve spontaneously and do not require treatment.

In addition, most postoperative surgical ICU patients have ventilatory support withdrawn rather quickly, reducing the need for a CXR to evaluate the endotracheal tube position. Moreover, because intrathoracic drains after thoracic surgery are placed under direct vision, evaluating their position with CXRs may not be necessary. Some investigators, therefore, have concluded that postoperative CXRs are only useful in cases in which there is a clear clinical indication to obtain one.[7, 12-15]

Unfortunately, most studies evaluating postoperative CXRs have thus far only reported on diagnostic efficacy; therapeutic efficacy has only been scarcely reported.[7] We hypothesized that the therapeutic efficacy of both clinically indicated and routinely obtained postoperative CXRs would be low. Therefore, in this study, we determined the diagnostic and therapeutic efficacy of postoperative CXRs for surgical ICU patients. In addition, we determined whether the diagnostic and therapeutic efficacies differ between surgical subgroups and whether efficacies depend on the timing of postoperative CXRs.

Materials and methods

This study is an extension of a cohort study on which we have previously reported.[12-14] However, contrary to our previous work, here we analyzed the CXRs of postoperative patients. The original study was approved by the local Ethics Committee of the Academic Center in Amsterdam, the Netherlands. Due to the observational nature of the study, the need for informed consent was waived.

Setting

The study was conducted in a 28-bed, closed format, mixed medical and surgical ICU. The study population included general surgery, cardiothoracic surgery and neurosurgery patients. All beds were equipped with a patient data management system (Metavision; iMDsoft, Sassenheim, the Netherlands).

Design

A prospective design was used for this study. Unit policy was to routinely order postoperative CXRs for all surgical ICU patients directly after ICU admission. If tubes and/or lines were scheduled to be inserted, CXRs were obtained shortly thereafter if it was considered safe to wait for the CXR. We considered the first CXR made within six hours of admission to the ICU to be the "postoperative CXR" of interest; timing of CXRs was defined as the elapsed time between ICU admission and the moment at which the CXR was actually performed.

Diagnostic and therapeutic efficacy

Diagnostic efficacy (the ratio between the number of CXRs with a new or progressive major predefined finding divided by the total number of CXRs) was used to indicate the value of the CXR for assisting in a diagnosis. Therapeutic efficacy (the number of CXRs resulting in a change in clinical management divided by the total number of CXRs) was used to indicate the influence of the CXR on the patient's clinical management. For study purposes, we defined an efficacy <15% as "low."

Data collection

We recorded the following demographic data: age, gender, APACHE II score, SAPS II, type of ICU admission, type of surgery, duration of mechanical ventilation and length of stay in the ICU. Radiographic data (timing of CXRs) were automatically collected from our radiology department information system.

Data about the diagnostic and therapeutic efficacy were determined as described previously.[12, 13] For the purposes of this study, ICU physicians were instructed to complete the specially developed data sheet printed on the back of standard CXR request forms. ICU physicians could mark the 1) indications for the CXR (in this case, postoperative CXR), 2) predefined clinically expected abnormalities (Table I) and 3) whether clinically expected abnormalities were "old" (i.e., already present on preceding CXRs) or "new" (i.e., not present on preceding CXRs). The collection of data began after a one-month trial period during which the specially developed data sheet was tested for practicality and to ascertain if all involved physicians adequately marked the options.

Attending radiologists interpreted all CXRs the day they were performed. Similar to the ICU

Table I.—*Findings (expected) on admittance chest radiographs for which ICU physicians and the radiologist could score.*

Abnormality	Comments
Large atelectasis	≥2 lobes
Large infiltrates	≥ lobe
'Severe' pulmonary congestion	
'Severe' pleural effusion	
Pneumothorax or pneumomediastinum	Any abnormal air collection
Malposition of oropharyngeal tube	<2 cm from carina or above stem cords
Malposition of intravenous lines	Tip in right atrium or outside lumen (pulmonary artery catheter: tip in right atrium), or change in position
Malposition of intra-aortic balloon pump	
Malposition of gastric tube	Tip outside the stomach
Malposition of drains	Displacement >5 cm or outside pleural space

Abnormalities were scored by residents or clinical fellows if expected, and – separately – by radiologist if present. ICU: Intensive Care Unit.

physicians, radiologists scored the CXRs for each patient. In cases where an abnormality was worsening, it was categorized as "new." Based on these data, the diagnostic value of postoperative CXRs was calculated.

CXRs resulting in a change in clinical management were determined as follows. For all CXRs, it was determined whether any action was taken due to the new findings. To assess this, we used medical records of the PDMS and the hospital information system. The study investigators searched for sputum culture orders, performance of a bronchoalveolar lavage for culture or the start of or change in antimicrobial therapy in the setting of unexpected infiltrates found on a CXR, repositioning of tubes in the setting of malpositioned orotracheal tubes (ignoring planned extubations), ultrasound studies of the thorax after discovering a massive pleural effusion on a CXR, the start or change in a medication (diuretics), the insertion of a pleural drain and the repositioning of devices in the case of malposition of a medical device other than an orotracheal tube (ignoring planned changes such as the removal of intravenous lines). Because study investigators were not involved in the daily care of patients and because ICU physicians were not aware of this part of the observation, the clinical relevance of the predefined abnormalities could not be evaluated in some cases, specifically in cases of large atelectasis and massive pulmonary congestion. Based on these data, the therapeutic value of postoperative CXRs was calculated.

Statistical analysis

All data were entered into a computerized database (Microsoft Access 2003; Microsoft Inc., Richmond, WA, USA). Patient and clinical characteristics were summarized using descriptive statistics. The number of CXRs divided into different time categories and clinical strata were

Table II.—*Characteristics of postsurgery patients with a CXR within 6 hours after admission to ICU.*

Patients, N.	670
Age, years, mean ± SD	62±15
Gender, male, N. (%)	430 (64%)
APACHE II, mean ± SD	16±6
SAPS II, mean±SD	36±14
Patient subgroups, N. (% of total)	
Cardiothoracic surgery	436 (65%)
Neurosurgery	60 (9%)
General surgery	174 (26%)
Length of stay, median [IQR]	
Cardiothoracic surgery	1.2 [0.9-2.8]
Neurosurgery	2.4 [1.1-6.3]
General surgery	1.9 [1.0-4.1]
Time between admission and first CXR, hours, median [IQR]	
Cardiothoracic surgery	1.6 [1.0-2.7]
Neurosurgery	2.1 [1.1-3.0]
General surgery	1.6 [1.0-2.8]
Time between CXR and orotracheal extubation, hours, median [IQR]	
Cardiothoracic surgery	13.5 [9.3-23.9]
Neurosurgery	23.2 [13.3-70.6]
General surgery	16.2 [8.5-61.5]
CXR after orotracheal extubation, N. (%)	5 (0.8%)

CXR: chest radiograph; APACHE: acute physiology and chronic health evaluation; SAPS: simplified acute physiology score.

expressed as percentages of their total number in the different groups. All analyses were performed using SPSS version 16.0 software (SPSS Inc., Chicago, IL, USA).

Results

Postsurgery patients and postoperative CXRs on ICU admission

Of 857 postsurgery patients, 670 had a CXR within 6 hours of ICU admission, 175 patients had a CXR after 6 hours from admission but within the first 24 hours of their stay in the ICU (these CXRs were left out of the analysis), and 12 patients had no CXR at all during the first 24 hours in the ICU. Baseline characteristics are shown in Table II. Neurosurgery patients had a longer length of stay (P<0.003) and were mechanically ventilated for a longer period of time (P<0.001) compared to cardiothoracic surgery and general surgery patients.

The majority of postoperative CXRs were obtained within the first 2 hours after ICU admission (Table III). The median time between admission to the ICU and the timing of postoperative CXRs was 1.7 (1.0-2.7) hours. In the

TABLE III.—*Diagnostic and therapeutic efficacy of postoperative CXRs.*

Timing of CXRs	<2 hours	2-4 hours	4-6 hours	All
CXRs, N.	397	213	60	670

Clinically indicated postoperative CXRs
Abnormalities: expected (E), found (diagnostic, D), and resulting in a change in therapy (therapeutic, T)

CXRs, N.	46 (11%)			24 (11%)			10 (17%)			80		
	E	D	T	E	D	T	E	D	T	E	D	T
Large atelectasis	5	1	0	2	0	0	0	0	0	7	1	0
Massive infiltrates	9	4	2	5	0	0	1	0	0	15	4	2
Severe pulmonary congestion	8	3	0	6	0	0	2	0	0	16	3	0
Massive pleural effusion	2	0	0	3	0	0	0	0	0	5	0	0
Pneumothorax or pneumomediastinum	4	2	0	3	0	0	0	0	0	7	2	0
Malposition of invasive devices	41	2	0	26	2	1	10	0	0	77	4	1
Other	3	0	0	1	0	0	0	0	0	4	0	0
Total no. of abnormalities	72	12	2	46	2	1	13	0	0	131	14	3
Total no. of CXRs with abnormalities	46	12	2	24	2	1	10	0	0	80	14	3
Diagnostic efficacy	12/46 (26%)			2/24 (8%)			0/10 (0%)			14/80 (18%)		
Therapeutic efficacy	2/46 (9%)			1/24 (4%)			0/10 (0%)			3/80 (4%)		

Routinely-obtained CXRs
Abnormalities: not expected, but found (diagnostic, D), and resulting in a change in therapy (therapeutic, T)

CXRs, N.	351 (89%)		189 (89%)		50 (83%)		590	
	D	T	D	T	D	T	D	T
Large atelectasis	2	1	–	–	–	–	2	1
Large infiltrates	4	2	1	1	–	–	5	3
Severe pulmonary congestion	5	0	5	0	1	0	11	0
Massive pleural effusion	4	1	–	–	–	–	4	1
Pneumothorax or pneumomediastinum	3	2	3	1	2	0	8	3
Malposition of invasive devices	35	15	16	8	4	1	55	24
Other	3	1	2	0	–	–	5	1
Total no. of abnormalities	56	22	27	10	7	1	90	33
Total no. of CXRs with abnormalities	50	18	23	7	6	1	79	26
Diagnostic efficacy	50/351 (14%)		23/189 (12%)		6/50 (12%)		79/590 (13%)	
Therapeutic efficacy	18/351 (5%)		7/189 (4%)		1/50 (2%)		26/590 (4%)	

Data are presented as absolute numbers, or as percentage of the total number of CXR per stratum.

vast majority of patients (99%), CXRs were performed prior to tracheal extubation; the median duration between the time of CXRs and the end of mechanical ventilation was 14.5 (9.4-39.8) hours. Most CXRs (590/670, 88%) were performed routinely (i.e., no abnormalities were expected, and CXRs were performed for no other reason than admission to the ICU itself).

Diagnostic and therapeutic efficacy of postoperative CXRs

The diagnostic efficacy of clinically indicated and routinely obtained CXRs was 18% (14/80) and 13% (79/590), respectively. However, the therapeutic efficacy of clinically indicated and routinely obtained CXRs was low at 4% (3/80) and 4% (26/590), respectively.

Of all 59 cases of invasive device malposition, 51% (N.=30) demonstrated that an endotracheal tube was either too deep or above the cords, and 29% (N.=17) had a malpositioned central venous line. Other cases of malpositioned devices included gastric tubes (15%, N.=9) and intra-aortic balloon pumps (5%, N.=3).

The diagnostic and therapeutic efficacy of clinically indicated CXRs decreased over time (i.e., more abnormalities were found and influenced clinical practice from postoperative CXRs made soon after admission to the ICU). The diagnostic and therapeutic efficacy of routinely obtained postoperative CXRs was independent of the timing of CXRs.

Subgroup analysis

The diagnostic efficacy of clinically indicated CXRs and routinely obtained CXRs was similar among subgroups (Table IV). The therapeutic efficacy was lowest in cardiothoracic surgery patients.

Table IV.—*Diagnostic and therapeutic efficacy of postoperative CXRs among subgroups.*

	Cardiothoracic surgery			Neurosurgery			General surgery			All		
CXRs, N.	436			60			174			670		
Clinically indicated post–operative CXRs Abnormalities: expected (E), found (diagnostic, D), and resulting in a change in therapy (therapeutic, T)												
CXRs, N.	51			8			21			80		
	E	D	T	E	D	T	E	D	T	E	D	T
0-2 hours	51	9	1	4	2	1	17	1	0	72	12	2
2-4 hours	29	1	0	3	0	0	14	1	1	46	2	1
4-6 hours	9	0	0	1	0	0	3	0	0	13	0	0
All no. of abnormalities	89	10	1	8	2	1	34	2	1	131	14	3
All no. of CXRs with abnormalities	51	10	1	8	2	1	21	2	1	80	14	3
Diagnostic efficacy	10/51 (20%)			2/8 (25%)			2/21 (10%)			14/80 (18%)		
Therapeutic efficacy	1/51 (2%)			1/8 (13%)			1/21 (5%)			3/80 (4%)		

Routinely–obtained post–operative CXRs Abnormalities: not expected, but found (diagnostic, D), and resulting in a change in therapy (therapeutic, T)	Cardiothoracic surgery		Neurosurgery		General surgery		All	
CXRs, N.	385		52		153		590	
	D	T	D	T	D	T	D	T
0-2 hours	38	18	6	0	14	4	56	22
2-4 hours	15	6	3	0	9	4	27	10
4-6 hours	2	0	1	0	4	1	7	1
All no. of abnormalities	55	24	10	0	27	9	90	33
All no. of CXRs with abnormalities	48	20	10	0	2	6	6	3
Diagnostic efficacy	48/385 (12%)		10/52 (19%)		21/153 (14%)		79/590 (13%)	
Therapeutic efficacy	20/385 (5%)		0/52 (0%)		6/153 (4%)		26/590 (4%)	

Data are presented as absolute numbers, or as percentage of the total number of CXR per stratum

Discussion

We investigated the clinical value of postoperative CXRs for postoperative patients in the ICU. Our findings can be summarized as follows: 1) the majority of post operative CXRs in our ICU are made without a clinical indication aside from admission to the ICU itself, 2) the diagnostic and therapeutic efficacy of postoperative CXRs for postsurgery ICU patients is low and independent of the type of surgery, and 3) the efficacy CXRs is not dependent on timing.

As far as we know, this is the largest study analyzing the clinical value of postoperative CXRs in a mixture of postoperative ICU patients, including cardiothoracic surgery, neurosurgery and general surgery patients. Seventy-nine abnormalities were found that would have been missed in the case that the CXRs had not been performed. However, only 26 of these abnormalities led to a change in therapy, and in the majority of cases, this only amounted to a change in the position of the endotracheal tube. In addition, the malpositioned tracheal tubes and central venous lines were most often found in cardiothoracic surgery patients in whom these devices are usually removed quickly (i.e., within hours, such as for endotracheal tubes or the following day, in the case of central venous lines). Consequently, the therapeutic efficacy of postoperative CXRs in our cohort was considered to be very low.

Several observational studies of daily routine CXRs have suggested that daily routine CXRs can be eliminated from clinical practice.[7, 15, 16] A recently published randomized trial by Hejblum et al.[17] confirmed that daily routine CXRs do not add to the care of critically ill patients. The results of our present study suggest the same is true for routinely obtained postoperative CXRs. Hornick et al. showed an even lower therapeutic efficacy in cardiothoracic surgery ICU patients; of 89 CXRs that were deemed unnecessary by surgical residents, 1% were found to alter patient management by detecting a malpositioned central line. They concluded that routine postoperative CXRs are only of value if the resident wishes to confirm or clarify clinical findings noted at the time of admission to the ICU.[16] Another study by Silverstein et al. showed a comparable low prevalence of abnormalities on routinely obtained CXRs in a surgical ICU; only 1% of found abnormalities resulted in a change in management.[18] In addition, Rao et al. showed that CXRs in cardiothoracic surgery patients are of very little value, and patients are adequately managed by performing CXRs only when clinically indicated.[7]

The therapeutic consequences of some abnormalities may seem tremendous. However, when one considers the large number of CXRs required to identify an abnormality that might change clinical management, the therapeutic efficacy of postoperative CXRs is very low. The results of our study suggest that the rational use of postoperative CXRs based on a clinical evaluation may be preferable to routine use. Thus, CXRs would be performed more on the basis of clinical criteria and not as a large survey. In addition, obtaining postoperative CXRs is not without risks; the loss of orotracheal tubes or indwelling catheters and hemodynamic deterioration may result from lifting and positioning patients. Although we did not perform a formal cost analysis in our investigation, it is obvious that a restrictive policy for ICU admission CXRs may lead to significant cost reductions. In addition, abandoning admission CXRs may lead to less radiation exposure for patients and may also lower the daily workloads of radiologists and radiology co-workers.

The results of our study can be interpreted in different ways. While we believe that the low diagnostic and therapeutic efficacy of routinely obtained postoperative CXRs should be seen as an argument to stop obtaining such CXRs, one could also postulate that "negative" findings (i.e., not finding a specific major abnormality) may also be an important sign for ICU physicians. Indeed, ICU physicians may want to know whether their expectations are correct and whether they should continue a patient's therapy; for this, they may use "negative" findings. Moreover, clinicians may tend to think of admission CXRs as a reference point if a patient's condition worsens during their stay in the ICU.

Our study shows that abnormalities found on postoperative CXRs are uncommon, but if found, they may lead to potentially life-saving interventions. This might also be used as an argument for not abandoning postoperative CXRs in daily practice. Unfortunately, there is a paucity of randomized controlled trial evidence about whether a strategy without routine postoperative CXRs is as safe as a strategy that uses these CXRs.

The purely descriptive and uncontrolled design of this investigation limits the interpretation of our findings. Additional studies are needed to determine whether abolishing routinely obtained postoperative CXRs is a safe strategy and whether it is as satisfactory for ICU physicians as obtaining routine CXRs for all postoperative ICU patients. Other important drawbacks of our study include the following: first, the requested behavior of physicians might have significantly influenced our analysis of the diagnostic value of CXRs. This was not controlled. Second, it must be noted that the present results might not reflect the results in other centers. Differences in staff and patient populations might be of great influence.

Conclusions

The clinical value of postoperative CXRs for surgical ICU patients is low. Considering the cost and labor associated with obtaining these CXRs, we believe that postoperative CXRs, and in particular those performed for no other reason than admission to the ICU itself, are an ineffective measure.

References

1. Brunel W, Coleman DL, Schwartz DE, Peper E, Cohen NH. Assessment of routine chest roentgenograms and the physical examination to confirm endotracheal tube position. Chest 1989;96:1043-5.
2. Lotano R, Gerber D, Aseron C, Santarelli R, Pratter M. Utility of postintubation chest radiographs in the intensive care unit. Crit Care 2000;4:50-3.
3. Sanabria A, Henao C, Bonilla R, Castrillón C, Cruz H, Ramírez W et al. Routine chest roentgenogram after central venous catheter insertion is not always necessary. Am J Surg 2003;186:35-9.
4. Lessnau KD. Is chest radiography necessary after uncomplicated insertion of a triple-lumen catheter in the right internal jugular vein, using the anterior approach? Chest 2005;127:220-3.
5. Quasney MW, Goodman DM, Billow M, Chiu H, Easterling L, Frankel L et al. Routine chest radiographs in pediatric intensive care units. Pediatrics 2001;107:241-8.
6. Abood GJ, Davis KA, Esposito TJ, Luchette FA, Gamelli RL. Comparison of routine chest radiograph versus clinician judgment to determine adequate central line placement in critically ill patients. J Trauma 2007;63:50-6.
7. Rao PS, Abid Q, Khan KJ, Meikle RJ, Natarajan KM, Morritt GN et al. Evaluation of routine postoperative chest X-rays in the management of the cardiac surgical patient. Eur J Cardiothorac Surg 1997;12:724-9.
8. Krivopal M, Shlobin OA, Schwartzstein RM. Utility of daily routine portable chest radiographs in mechanically ventilated patients in the medical ICU. Chest 2003;123:1607-14.
9. Schultz MJ. Daily routine chest radiographs. Chest 2004;125:1167-9.
10. Graat ME, Stoker J, Vroom MB, Schultz MJ. Can we abandon daily routine chest radiography in intensive care patients? J Intensive Care Med 2005;20:238-46.
11. Hendrikse KA, Gratama JW, Hove W, Rommes JH, Schultz MJ, Spronk PE. Low value of routine chest radiographs in a mixed medical-surgical ICU. Chest 2007;132:823-8.
12. Graat ME, Choi G, Wolthuis EK, Korevaar JC, Spronk PE, Stoker J et al. The clinical value of daily routine chest radiographs in a mixed medical-surgical intensive care unit is low. Crit Care 2006;10:R11.
13. Graat ME, Kröner A, Spronk PE, Korevaar JC, Stoker J, Vroom MB et al. Elimination of daily routine chest radiographs in a mixed medical-surgical intensive care unit. Intensive Care Med 2007;33:639-44.
14. Kröner A, Binnekade JM, Graat ME, Vroom MB, Stoker J, Spronk PE et al. On-demand rather than daily-routine chest radiography prescription may change neither the number nor the impact of chest computed tomography and ultrasound studies in a multidisciplinary intensive care unit. Anesthesiology 2008;108:40-5.
15. McCormick JT, O'Mara MS, Papasavas PK, Caushaj PF. The use of routine chest X-ray films after chest tube removal in postoperative cardiac patients. Ann Thorac Surg 2002;74:2161-4.
16. Hornick PI, Harris P, Cousins C, Taylor KM, Keogh BE. Assessment of the value of the immediate postoperative chest radiograph after cardiac operation. Ann Thorac Surg 1995;59:1150-3.
17. Hejblum G, Chalumeau-Lemoine L, Ioos V. Comparison of routine and on-demand prescription of chest radiographs in mechanically ventilated adults: a multicentre, cluster-randomised, two-period crossover study. Lancet 2009;374:1687-93.
18. Silverstein DS, Livingston DH, Elcavage J, Kovar L, Kelly KM. The utility of routine daily chest radiography in the surgical intensive care unit. J Trauma 1993;35:643-6.

Received on November 5, 2009 - Accepted for publication on September 22, 2010.

Corresponding author: A. Kröner, Department of Intensive Care Medicine, Academic Medical Centre, Meibergdreef 9, 1105 AZ Amsterdam, the Netherlands. E-mail: a.kroner@amc.uva.nl