Postoperative infections after major heart surgery and prevention of ventilator-associated pneumonia: a one-day European prevalence study (ESGNI-008)

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Received 21 March 2006; accepted 15 June 2006
Available online 22 August 2006

KEYWORDS
Intensive care unit; Major heart surgery; Nosocomial infection; Prevention; Risk factors; Ventilator-associated pneumonia; Cardiovascular surgery; Cardiac surgery

Summary Few data have been published on the prevalence of postoperative infection in patients undergoing major heart surgery (MHS). The degree of compliance with standard measures used to prevent them is unknown. This study assessed the prevalence of infections, particularly ventilator-associated pneumonia (VAP), in patients undergoing MHS in 42 institutions from 13 European countries. On the study day, there were 321 postoperative MHS patients, of whom 164 (51%) were mechanically ventilated. The overall prevalence of infection was 26.8%. Lower respiratory tract infections represented 57% of all the infections present on the study day. Other infections included intravenous-catheter-related...
Introduction

Ventilator-associated pneumonia (VAP) is the most common nosocomial infection in general intensive care units (ICUs), and represents 31% of all ICU-acquired infections.1,2 It is also a leading cause of morbidity with rates of associated mortality ranging from 20% to 70%.3,4

Patients undergoing major heart surgery (MHS) represent a special subpopulation. Data regarding postoperative infections, particularly VAP, in this group are scarce, and usually come from single institutions.5,6 Welsby et al. reported recently that infection was the main non-cardiac complication in 2564 patients undergoing MHS.7

In a report from a single institution in Madrid, Spain, VAP occurred in 8% of all patients undergoing MHS and resulted in 35 clinical episodes per 1000 days of ventilation.8 The high mortality associated with VAP suggests that it should be considered more of a complication to be prevented rather than an infection to be treated. Adherence to measures recommended to prevent VAP has been estimated at between 20% and 100% in general ICUs,9 but the authors were not able to find any relevant multi-centre study data for patients undergoing MHS.

Measures recommended to prevent VAP include nursing patients in a semi-recumbent position, continuous aspiration of subglottic secretions, maintaining adequate intracuff pressure, avoiding gastric overdistension, and use of heat-moisture exchangers (HMEs).

The aim of this study was to determine the prevalence of nosocomial infections in patients undergoing MHS in Europe, and to assess the rates of adherence to recommendations designed to prevent VAP.

Materials and methods

The study (ESGNI-008) was a voluntary, one-day prevalence study held on 13 November 2002. A standardized, four-part questionnaire was sent to members of the European Workgroup of Cardiothoracic Intensivists working in hospitals across Europe.

The first set of information requested data regarding the type of hospital (public or private, teaching or non-teaching), total population served, number of beds, and number of hospital admissions of 24-h duration or longer during 2001.

The second set of questions was about the ICU, and asked whether the ICU was a mixed general unit or used exclusively for cardiothoracic patients, the number of available beds, the facilities available to isolate patients with nosocomial infections, medical and nursing staff numbers, the number of patients who underwent surgery in 2001, and the number of beds occupied by MHS patients on the study day.

The third part of the questionnaire asked about the number of ventilated, postoperative cardiac patients, the number of ventilated patients in a semi-recumbent position, the use of intracuff pressure monitoring, the type of HMEs used, the use of continuous subglottic suctioning, the control of gastric overdistension, the use of postural oscillation or rotation, the use of selective digestive decontamination, the type of stress ulcer prophylaxis used, and the number of patients receiving continuous sedation.
The final section included data on the total number of patients with nosocomial infections, the types of nosocomial infection and the number of patients receiving antimicrobial chemotherapy on the study day.

Infections were defined as follows.

- Intravenous-catheter-related bloodstream infection: isolation of the same micro-organism (i.e. identical species and antibiogram) from a semi-quantitative or quantitative culture of a catheter segment and from the blood (preferably drawn from a peripheral vein) of a patient with accompanying clinical symptoms of sepsis and no other apparent source of infection.10
- Nosocomial endocarditis: defined according to the modified Duke criteria proposed by Li et al. as endocarditis occurring >72 h after admission to hospital and directly related to a hospital-based procedure performed during the current hospital admission or during a previous admission.11
- Surgical site infection: defined according to the Centers for Disease Control and Prevention (CDC).12
- Postsurgical mediastinitis: purulent discharge from the mediastinal area in association with partial or complete sternal dehiscence.10
- Purulent tracheobronchitis: presence of purulent tracheobronchial secretions plus two or more of the following criteria: fever (≥38.5 °C) or hypothermia (<36 °C), leucocytosis (≥12 x 10⁹/L) or significant bacteriological counts in respiratory secretions from patients without pulmonary infiltrates suggesting pneumonia on chest radiograph.10
- VAP: new and/or progressive pulmonary infiltrates on chest X-ray plus two or more of the following criteria: fever (≥38.5 °C) or hypothermia (<36 °C), leucocytosis (≥12 x 10⁹/L), purulent tracheobronchial secretions, a reduction in PaO₂/FiO₂ (partial pressure of arterial oxygen/fraction of inspired oxygen) by 15% or more in the last 48 h,10 or a Pugin score >6.13
- Nosocomial urinary tract infection: positive urine culture (>10⁴ colony-forming units/mL of no more than two different species) obtained at least 48 h after hospital admission.
- The ICUs were classified as specifically cardiac (more than 95% of their beds were for patients undergoing MHS) or mixed.

Data analysis

All reports received from individual centres were reviewed by one of the authors before being entered into the database and analysed using SPSS Version 12 (SPSS Inc., Chicago, Illinois, USA).

Continuous variables were expressed as the mean, standard deviation and 95% confidence interval when normally distributed, or as the median and interquartile range (IQR) when their distribution was skewed. Discrete variables were expressed as percentages.

Results

Overall, 42 hospitals in 13 different European countries participated in the study (Table I). The total number of patients who underwent MHS during the previous year in the different participating centres was 25 570 (median per institution 487, IQR 321–854).

The 42 participating institutions were classified as either teaching (83.3%) or non-teaching hospitals (16.7%). The majority were public hospitals (85.7%) of different sizes. The distribution of hospitals according to the number of beds available was as follows: <500 beds (23.8%), 500–1000 beds (33.3%) and >1000 beds (42.9%). These institutions provided health care for 32 194 573 Europeans (median 530 510, IQR 400 000–1 000 000), and they had 1 578 894 admissions (median 35 316, IQR 16 059–50 594) during 2001. Therefore, there were an estimated 79.4 MHS interventions per 100 000 inhabitants and 16.13 procedures per 1000 hospital admissions.

Only 43% of the ICUs were used exclusively for MHS patients. The median number of available beds in those units was 11 (IQR 8.25–20). The median number of patients per independent room was three (IQR 1–6). All units were able to isolate patients in single rooms.
The median ratio of nurses per bed and per shift was 0.85 (IQR 0.7–1.1), and the median ratio of physicians per bed and day was 0.73 (IQR 0.5–1.0).

On the study day, there were 321 postoperative MHS patients (median 7.0/unit, IQR 4.7–9.2) and 164 (51%) were receiving mechanical ventilation (median 4.0/unit, IQR 2–5.2). Compliance with recommendations designed to prevent VAP is summarized in Table II.

The overall prevalence of nosocomial infections in postoperative cardiac patients in ICUs on the study day was 26.8% (86 patients in total). Lower respiratory tract infections were present in 49 patients (15.3%) and represented 57% of all infections. Of the lower respiratory tract infections, 25 were tracheobronchitis (7.8%) and 24 were VAP (7.5%). Other infections are summarized in Table III.

Almost 60% of the hospitals in the study were Spanish; however, there were no statistically significant differences between Spanish and non-Spanish institutions in numbers of nosocomial infections: pneumonia (10.5% vs 5.0%; \( P = 0.32 \)), tracheobronchitis (9.0% vs 5.25%; \( P = 0.22 \)), intravenous-catheter-associated bloodstream infection (2.66% vs 3.65%; \( P = 0.56 \)), surgical site infection (1.68% vs 2.19%; \( P = 0.98 \)), urinary tract infection (1.33% vs 2.11%; \( P = 0.57 \)), mediastinitis (2.13% vs 0.53%; \( P = 0.75 \)), nosocomial endocarditis (1.0% vs 0.59%; \( P = 0.81 \)) and other major infections (3.93% vs 1.32%; \( P = 0.44 \)).

Discussion

To the best of the authors’ knowledge, this is the first European study to assess the prevalence of infections in patients after MHS during their ICU stay. It shows a high prevalence of ICU-acquired infection in a large set of European institutions (26.8%). This figure is higher than the 20.6% reported in the EPIC Study, which included all types of ICU and was carried out over a decade ago.

Postoperative infection is the main non-cardiac complication after MHS and has been clearly related to increased morbidity, use of hospital resources and mortality.\(^5,7\) VAP is the main cause of postoperative infection in patients undergoing MHS,\(^5,6\) and, together with tracheobronchitis, was also the main nosocomial infection in the present study (57%). VAP in general ICUs has been associated with excessive attributable mortality and significant attributable costs.\(^14–16\) Prevention of nosocomial infections, including VAP, has been proposed as an important management objective for all hospitals and different recommendations have been issued in this respect.\(^17–19\) Unfortunately, compliance with recommendations varies considerably between general ICUs.\(^9,20\)

Cook et al. compared Canadian and French ICUs using seven strategies to control secretions and care for ventilator circuits in order to prevent VAP and reduce overall healthcare costs.\(^21\) Adherence to specific prevention recommendations for VAP was more common among French ICUs (64% vs 30%, \( P = 0.002 \)), but rates were low in both countries. The present study showed a low rate of adherence to different potential preventive measures against VAP in patients undergoing MHS in Europe.

Positioning the supine patient in a semi-recumbent position at an angle of 30–45° elevation receives a category IB recommendation in the CDC guidelines, assuming there is no medical contraindication precluding it.\(^19\) Haemodynamic instability after MHS may make this position impossible, but two-thirds of patients were being nursed in this position on the study day.

### Table II
<table>
<thead>
<tr>
<th>Variables</th>
<th>Number of patients</th>
<th>Number of patients %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-recumbent body position</td>
<td>109</td>
<td>66.5</td>
</tr>
<tr>
<td>Heat-moisture exchanger with antibacterial filters</td>
<td>128</td>
<td>88.0</td>
</tr>
<tr>
<td>Control of pressure in endotracheal tube cuff</td>
<td>86</td>
<td>52.4</td>
</tr>
<tr>
<td>Continuous subglottic suctioning</td>
<td>13</td>
<td>8.0</td>
</tr>
<tr>
<td>Postural oscillation</td>
<td>100</td>
<td>61.0</td>
</tr>
<tr>
<td>Prevention of gastric overdistension</td>
<td>141</td>
<td>86.0</td>
</tr>
<tr>
<td>Topical antimicrobial prophylaxis</td>
<td>11</td>
<td>3.4</td>
</tr>
<tr>
<td>Selective digestive decontamination</td>
<td>7</td>
<td>2.0</td>
</tr>
</tbody>
</table>

### Table III
<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>% of all patients</th>
<th>% of all infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower respiratory tract infection (total)</td>
<td>49</td>
<td>15.3</td>
<td>57</td>
</tr>
<tr>
<td>Ventilator-associated pneumonia</td>
<td>24</td>
<td>7.5</td>
<td>27.9</td>
</tr>
<tr>
<td>Tracheobronchitis</td>
<td>25</td>
<td>7.8</td>
<td>29.1</td>
</tr>
<tr>
<td>Catheter-related bloodstream infection</td>
<td>9</td>
<td>2.8</td>
<td>10.5</td>
</tr>
<tr>
<td>Surgical site infection</td>
<td>7</td>
<td>2.2</td>
<td>8.2</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>6</td>
<td>1.9</td>
<td>7</td>
</tr>
<tr>
<td>Mediastinitis</td>
<td>3</td>
<td>0.9</td>
<td>3.5</td>
</tr>
<tr>
<td>Nosocomial endocarditis</td>
<td>2</td>
<td>0.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Other infections</td>
<td>10</td>
<td>3.1</td>
<td>11.5</td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
<td>26.8</td>
<td>100</td>
</tr>
</tbody>
</table>
Some studies have reported a reduced incidence of VAP with the use of HMEs instead of conventional heated-water humidification systems, while other studies have not. This is a CDC category II recommendation. All patients surveyed in the present study had HMEs but 22% had no antibacterial filters.

A recent meta-analysis including five studies and 896 patients concluded that continual subglottic succioning appears to be effective in preventing early-onset VAP among patients expected to be ventilated for over 72 h. However, in MHS patients, the use of subglottic aspiration significantly delayed the development of VAP, but did not reduce its incidence overall (5% vs 8% ; \( P = 0.24 \)).

Despite the CDC’s category IB recommendation, this study demonstrated that continuous subglottic succioning, which was not applied to 92% of patients, is still not common practice among ventilated cardiac surgery patients in Europe.

Although recommended previously, maintenance of adequate intracuff pressure to prevent VAP is no longer included as a recommendation in the most recent CDC guidelines. On the study day, cuff pressure was not being monitored in almost half of the patients.

No firm recommendation can be made for the routine use of oscillation or rotational therapy, either by 'kinetic' therapy or by continuous lateral rotational therapy, for the prevention of healthcare-associated pneumonia in critically ill or immobiledized patients. Postural oscillation/rotation was not being used in 64 (39%) patients in the present study.

The modulation of oropharyngeal colonization, either with antibiotics or chlorhexidine, selective decontamination of the digestive tract, and systemic administration of antimicrobials is still controversial. Most studies show a reduction in the incidence of VAP, but reductions in mortality have been demonstrated less frequently. The procedure is cumbersome and time-consuming, and the main drawback of these measures is the potential for widespread antimicrobial resistance in ICUs.

The present study shows the low acceptance of some of these practices among patients undergoing MHS in Europe. Topical antimicrobial prophylaxis with non-absorbable antibiotics was only administered to 11 patients (3.4%), and antimicrobials for selective decontamination of the digestive tract were only administered to seven patients (2%). This is recognized as an unresolved issue in the most recent CDC recommendations.

The limitations of the present study include a tendency to overestimate infection in prevalence studies, the voluntary involvement of the participating institutions, and the potential changes in the recommendations and practice between the study day and the publication of this paper. Another potential limitation is the disproportionately high number of Spanish hospitals enrolled in the study; however, no significant differences were found between data from hospitals in Spain and in other European countries.

This is the largest assessment of the prevalence of infection in patients undergoing MHS to date, and clearly shows that improvement in the measures used to prevent VAP in patients undergoing MHS is required in many European institutions.

Acknowledgements

The authors thank Thomas O’Boyle for his review of the English version of the manuscript and Cristina Fernández for her contribution to the statistical analysis. The study was supported, in part, by Red Española de Investigación en Patología Infecciosa (REIPI - CO3/14) and by a grant from the Spanish Social Security Health Investigation Fund (FIS PI-021136).

References

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Appendix 1

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