Combined Epidural and General Anesthesia versus General Anesthesia for Abdominal Aortic Surgery

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The goal of this randomized study of high-risk surgical patients was to determine whether intraoperative thoracic epidural anesthesia in combination with light general anesthesia alters postoperative morbidity when compared to a standard technique of "balanced" general anesthesia. A total of 173 patients scheduled for abdominal aortic reconstruction were admitted to the study; 86 were to receive "balanced" general anesthesia (group 1) and 87 thoracic epidural anesthesia in combination with light general anesthesia (group 2). Preoperative evaluation included standard clinical tools, dipyridamole thallium gammatomography, and radionuclide angiography. In these patients, all of whom had peripheral artery disease, there were no significant differences in associated coronary artery disease, hypertension, and cardiovascular treatment. The distribution of left ventricular ejection fraction and the number of patients with thallium redistribution were not statistically different between the two groups. During the postoperative period, group 1 received analgesia of subcutaneous morphine (n = 35), epidural fentanyl (n = 30), or epidural bupivacaine (n = 21). In group 2, 6 patients with a nonfunctioning epidural catheter due to technical failure received a balanced general anesthesia and were eliminated from the study. During the postoperative period, group 2 received analgesia of subcutaneous morphine (n = 26), epidural fentanyl (n = 25), or epidural bupivacaine (n = 30). Cardiovascular morbidity did not differ between the two groups: 22 patients in group 1 and 19 patients in group 2 had a major postoperative cardiac event. Myocardial infarction was diagnosed in 5 patients in each group, congestive heart failure in 7 patients in group 1 and 5 patients in group 2, and prolonged myocardial ischemia in 16 patients in each group. Respiratory morbidity was extremely high (61% in group 1 and 55% in group 2) and not significantly different between the two groups. The major part of this respiratory morbidity consisted of minor atelectasis. Acute respiratory failure occurred in 8 patients in group 1 and in 4 patients in group 2. Four patients in group 1 and 3 patients in group 2 died. We conclude that thoracic epidural anesthesia in combination with light general anesthesia is not preferable to general anesthesia in high-risk surgical patients. This study does not exclude the possibility that postoperative epidural analgesia may favorably influence postoperative outcome. (Key words: Anesthetic techniques: thoracic epidural. Surgery, complications: postoperative morbidity; myocardial infarction; congestive heart failure; pulmonary complications.)

AN IMPROVED UNDERSTANDING of the physiologic changes resulting from anesthesia and surgery in high-risk surgical patients has led to decreased postoperative morbidity and mortality over the past decades. Yet, major surgical procedures are still associated with morbidity: myocardial infarction, pulmonary complications, and renal or hepatic failure. Recent interest has therefore focused on the possible beneficial effects of regional anesthesia techniques to reduce postoperative morbidity.[1-6] Several investigations have been performed comparing combined epidural and light general anesthesia with general anesthesia.[6-9] The most striking results were those described in the study by Yeager et al.[6] In patients receiving epidural anesthesia and postoperative epidural analgesia, they found a reduction in postoperative mortality, overall postoperative complication rate, and incidence of cardiovascular failure and major infections compared to those of a group of patients receiving general anesthesia. These authors suggested that epidural anesthesia and especially postoperative care, including epidural analgesia with opioids and/or local anesthetics, could be what ultimately determines morbidity and mortality. No study, however, has examined the isolated effect of primary anesthetic technique per se on postoperative outcome in a large population of high-risk patients.

The goal of the current randomized study was to determine in patients scheduled for abdominal aortic surgery whether intraoperative thoracic epidural anesthesia in combination with light general anesthesia alters postoperative morbidity when compared to a standard technique of "balanced" general anesthesia. The number of patients to be included in the study was prospectively established from a known incidence of postoperative complications associated with this type of surgery.

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Material and Methods

PATIENTS

From January 1, 1988 to May 1, 1989, all patients referred to the Vascular Surgery Department of the Pitié-Salpétrière Hospital for elective abdominal aortic reconstructive surgery were prospectively evaluated to determine if they were to be included in this study. Each patient

was seen in consultation by a staff anesthesiologist. Twelve-lead electrocardiogram (ECG) at rest, standard biochemical assays, functional respiratory tests, arterial blood gases, chest x-ray, dipyridamole thallium gammatomography, and gated radionuclide angiography were obtained in all patients, as usually done in the Vascular Surgery Department.

Dipyridamole thallium gammatomography was performed 1–10 days before surgery. Images were interpreted qualitatively by two independent observers unaware of the patients' clinical findings. Thallium scans showing defects on the initial images were considered abnormal. Perfusion defects were further categorized as having redistribution if the defect filled in on the delayed images or as persistent defects if they did not fill in.[10] The number of myocardial areas with a defect and with redistribution was recorded for each patient.

To determine left ventricular ejection fraction and to analyze wall motion, gated radionuclide angiography[11] was performed the same day as dipyridamole thallium gammatomography. Left ventricular ejection fraction was derived from end-diastolic and systolic counts using standard formulas. Measurements were repeated twice by two experienced physicians. The mean values were retained. In the nuclear medicine laboratory, the normal value for left ventricular ejection fraction is 0.64 ± 0.05, and inter- and intraobserver variability is less than 5%. Left ventricular regions were automatically subdivided into 16 equiangular sectors around the center of mass, and a sectorial ejection fraction was calculated in each sector. A sectorial ejection fraction of less than two standard deviations when compared to the normal value defined a regional wall motion abnormality.

INCLUSION CRITERIA

Criteria for inclusion were 1) elective abdominal aortic surgery for aneurysm or aortoiliac occlusive disease; 2) absence of contraindications to epidural anesthesia (preoperative coagulopathy, localized infection, or septicemia and graft sepsis); 3) left ventricular ejection fraction greater than 35%; and 4) aortic surgical procedure performed *via* a midline xiphopubic skin incision. Those patients who met all the criteria were randomized from a table of random numbers to receive either balanced general anesthesia (group 1) or thoracic epidural anesthesia combined with light general anesthesia (group 2). Informed consent was obtained, and the protocol was approved by our Ethics Committee.

ANESTHETIC AND POSTOPERATIVE MANAGEMENT

In both groups, the preoperative cardiac treatment was followed until 2 h before surgery. Morphine (0.1 mg/kg) and scopolamine (6 μg/kg) were administered intramus-

cularly 2 h before induction. The same monitoring was used for all patients. ECG and ST-segment analysis (leads D2, CS5, and V4) (Marquette 7010 Monitor) were continuously monitored throughout the preoperative and intraoperative period. Standard ECG monitoring was used during the postoperative period. Hemodynamic variables using radial artery and pulmonary artery catheters were monitored continuously perioperatively.

In group 1, general anesthesia was induced using fentanyl (6 μg/kg), flunitrazepam (0.02 mg/kg), and pancuronium bromide (0.1 mg/kg) and was maintained under controlled ventilation (50% nitrous oxide in oxygen) by increments of fentanyl (approximately 1.5 μg/kg every 20 min) and pancuronium bromide. When required, a low concentration of isoflurane was administered to maintain anesthesia. Isoflurane concentration was increased to control arterial blood pressure during aortic cross clamping.

In group 2, an epidural catheter was inserted *via* the T8–T9 interspace. Thoracic epidural anesthesia was then induced using an initial 10-ml dose of a mixture of plain bupivacaine 0.5% and lidocaine 2%; if necessary, additional incremental doses to a total as great as 16 ml were administered until a thoracoabdominal sensitive blockade was induced. The level of anesthesia was determined by the loss of pin-prick sensation. During the onset of epidural anesthesia, a standard volume of colloids (7 ml/kg) was infused and when systolic arterial blood pressure decreased below 100 mmHg, ephedrine was injected in increments of 6 mg. General anesthesia was induced using flunitrazepam (0.02 mg/kg), fentanyl (6 μg/kg), and pancuronium bromide (0.1 mg/kg). After tracheal intubation, anesthesia was maintained under controlled ventilation (50% nitrous oxide in oxygen) by continuous epidural infusion (6–8 ml/h) of the described mixture. When required, a low concentration of isoflurane was administered to maintain anesthesia. Isoflurane concentration was increased to control arterial blood pressure during aortic cross-clamping. Six patients with a nonfunctioning epidural catheter received general anesthesia and were eliminated from the study.

In both groups, fluid infusion, transfusion management and ephedrine administration were based on microhematocrit measurements and on hemodynamic monitoring and were under the direction of the attending anesthesiologist. Maximal hemodynamic changes (lowest and highest systolic arterial pressure and lowest and highest heart rate) were recorded. Postoperative analgesia was left to the responsibility of the attending anesthesiologist and was not dictated by the study protocol. Postoperative analgesia in the vascular surgery unit was achieved with one of three techniques: subcutaneous administration of morphine (5–10 mg morphine repeated 4–6 times a day), epidural bupivacaine (6–10 ml/h of bupivacaine 0.25%),

and epidural fentanyl ($1 \ \mu g \cdot kg^{-1} \cdot h^{-1}$). The postoperative analgesia technique was planned preoperatively by the anesthesiologist in charge of the patient, and if a patient in group 1 needed an epidural catheter, it was inserted before induction.

Postoperatively, ECG (lead CM5) (Hewlett Packard Monitor) and hemodynamic variables were continuously monitored for at least 24 h in an intensive care unit. Twelve-lead ECG recordings were repeated at the end of surgery, 3 h later, every time ST depression or premature ventricular complexes were detected on the electrocardioscope, and daily during the first 10 postoperative days. Chest x-rays were also repeated daily at least during the first 6 postoperative days. Postoperative care, including continuous hemodynamic monitoring and treatment, mechanical ventilation, extubation, and standardized nursing care, was under the supervision of the attending anesthesiologist in charge of the intensive care unit and was not dictated by the study protocol. Patients remained in the intensive care unit until the physicians caring for them determined that they could be transferred to a surgical ward.

CLINICAL OUTCOME ANALYSIS

Major clinical outcome variables prospectively analyzed were mortality and major cardiac morbidity. Mortality was defined as death occurring during the hospital period after the surgical procedure.

A postoperative cardiac complication was defined as the appearance of either prolonged myocardial ischemia, myocardial infarction, congestive heart failure, or ventricular tachyarrhythmia:

- Prolonged myocardial ischemia was defined as a new ST–T abnormality (ST depression greater than 1 mm or T-wave inversion) on at least two successive daily 12-lead ECG recordings.
- The diagnosis of postoperative myocardial infarction required diagnosis at autopsy, new Q waves of at least 0.04 s and minimal 1 mm in depth on the ECG, or ST–T segment depression (greater than 1 mm) lasting more than three consecutive days on the daily 12-lead ECG. Cardiac enzymes obtained daily for all patients were not used for myocardial infarction diagnosis.
- Congestive heart failure was defined as the postoperative need for sympathomimetic support and the associated hemodynamic and pulmonary symptoms: classic chest x-ray changes, persistent pulmonary capillary wedge pressure greater than 18 mmHg, and a new impairment in left ventricular function on postoperative echocardiography.
- Ventricular tachyarrhythmia was defined as documented ventricular tachycardia or fibrillation.

A postoperative respiratory complication was defined as the occurrence of either atelectasis (minor or major), pneumonia (confirmed or suspected), or acute respiratory failure:

- A minor atelectasis was defined as the presence of lamellar atelectasis on chest x-rays.
- A major atelectasis was defined as the presence of segmental or large atelectasis on chest x-rays.
- A confirmed pneumonia was defined in the absence of other localized infection, as the new appearance of an infiltrate on chest x-rays, associated with purulent sputum, a temperature of 38.5° C or higher, abnormal elevation of white blood cell count, and favorable outcome after antibiotic treatment.
- The diagnosis of suspected pneumonia was defined as a new infiltrate on chest x-rays associated with a temperature of 38° C or higher and a favorable outcome after antibiotic treatment, without obvious elevation of white blood cell count or if another localized infection could not be excluded.
- Acute respiratory failure was defined in the presence of atelectasis or pneumonia as the postoperative need for mechanical ventilation for more than 24 h or the clinical need to reintubate the trachea and mechanically ventilate the lungs.

Also prospectively considered were other major postoperative complications:

- Renal failure was defined as an increase in serum creatinine to more than 200 μM.
- Gastrointestinal bleeding was defined as the sudden appearance, unrelated to the surgical procedure, of nasogastric or rectal bleeding associated with decrease in hemoglobin of at least 2 g/dl in the absence of any other source of ongoing bleeding.
- Sepsis was defined by the presence of a localized infection with clinical evidence of bacteremia with chills, rigors, fever, elevated white blood cell count, and at least one positive blood culture.
- Major surgical complication was defined as the need to reoperate due to hemorrhage, peripheral or intestinal ischemia, or midline incision complications.

STATISTICAL ANALYSIS

Considering an overall cardiovascular morbidity of 25% and an overall respiratory complication rate of 50%, we calculated that 130–160 patients would be needed to show a difference of 20% in the cardiac complications rate and 30% in the respiratory complications rate with a type I and type II error of 5%. Since the approximate inclusion rate could be 10 patients a month, the study was scheduled to take place over a period of 16 months. No qualitative

or quantitative interpretation of the data was made before the study was completed.

Standard descriptive statistics were used to characterize each variable. Normality of the distribution of continuous numeric variables was studied using the Kolmogorov-Smirnov test and the chi-squared test. For these variables, intergroup comparisons were achieved using two-sample t test when the distribution of the variable was normal and the Mann-Whitney U-test when the distribution was not normal. Intergroup comparisons for ordinal variables were made using the chi-squared test and Fisher's Exact Test for 2×2 tables. Patients with a missing value on a given variable were excluded from the comparison. All P values were two-sided, and significance was assessed at the 0.05 level.

Results

PATIENT CHARACTERISTICS

One hundred seventy-three patients were included in the study and were randomly assigned either to group 1, general anesthesia (n = 86) or to group 2, thoracic epidural anesthesia combined with light general anesthesia (n = 87). Since 6 patients in group 2 had a nonfunctioning epidural catheter, only 81 patients were maintained in the analysis. The demographic characteristics of the patients are shown in table 1. There was no significant difference with respect to these parameters. Preoperative cardiac and respiratory evaluation revealed no significant differences between the two groups (tables 2 and 3).

ANESTHESIA AND ANALGESIA

In group 1, all patients received balanced general anesthesia. During the postoperative period, analgesia was performed using either subcutaneous morphine (n = 35), epidural fentanyl (n = 30), or epidural bupivacaine (n = 21). In group 2, six patients had a nonfunctioning epidural catheter due to technical failure, received a balanced general anesthesia, and were eliminated from the study. Other patients received epidural anesthesia combined with light general anesthesia. During the postoperative

TABLE 1. Demographic Characteristics of the 167 Patients

	Group 1	Group 2	P
Age (mean ± SD)	62 ± 10	61 ± 10	0.48 (NS)
Sex ratio (men/women)	81/5	70/11	0.14 (NS)
Abdominal aortic aneurysm	52	41	0.26 (NS)
Aortoiliac occlusive disease	34	40	0.26 (NS)
Suprarenal cross-clamping	8	13	0.28 (NS)

Group 1: general anesthesia; group 2: thoracic epidural anesthesia in combination with light general anesthesia.
NS = nonsignificant.

TABLE 2. Preoperative Cardiac Evaluation of the 167 Patients

	Group 1	Group 2	P
Previous myocardial infarction	13	15	0.70 (NS)
Previous coronary artery graft	4	5	0.93 (NS)
History of angina	17	14	0.83 (NS)
ST–T abnormalities	13	15	0.70 (NS)
Rhythm other than sinus	2	6	0.24 (NS)
Hypertension	38	35	0.98 (NS)
Treated	35	34	0.99 (NS)
Controlled	34	29	0.73 (NS)
Cardiovascular treatment			
Long-acting nitrates	6	9	0.51 (NS)
Converting enzyme inhibitor	8	9	0.90 (NS)
β Blockers	8	9	0.90 (NS)
Calcium channel blockers	28	20	0.34 (NS)
α Blockers	4	2	0.73 (NS)
Central vasodilatator	3	6	0.44 (NS)
Cordarone	2	3	0.94 (NS)
Diuretics	6	12	0.17 (NS)
Digitalis	0	2	0.45 (NS)
Mean left ventricular ejection fraction	54 ± 8	56 ± 7	0.17 (NS)
Left ventricular ejection fraction <50%	20	10	0.14 (NS)
Regional wall motion abnormality	12	11	0.87 (NS)
Thallium defect	55	48	0.57 (NS)
Thallium redistribution	38	35	0.98 (NS)

Group 1: general anesthesia; group 2: thoracic epidural anesthesia in combination with light general anesthesia.
NS = nonsignificant.

period, analgesia was performed using either subcutaneous morphine (n = 26), epidural fentanyl (n = 25), or epidural bupivacaine (n = 30). No significant difference with respect to analgesic technique was observed between the number of patients included in each group. Intraoperatively, maximal hemodynamic changes were compared, and highest and lowest systolic arterial pressures were found to be slightly but significantly different between the two groups (fig. 1). Other maximal hemodynamic changes were not significantly different (fig. 1). The mean dose of ephedrine per patient used during anesthesia was considerably higher in group 2 than in group 1 (44.4

TABLE 3. Preoperative Respiratory Evaluation of the 167 Patients

	Group 1	Group 2	P
Chronic obstructive pulmonary disease	40	33	0.51 (NS)
Respiratory insufficiency	1	4	0.34 (NS)
Vital capacity <80%	17	8	0.12 (NS)
Residual volume >120%	26	15	0.11 (NS)
P_{O_2} < 65 mmHg	9	12	0.54 (NS)
P_{CO_2} > 45 mmHg	2	1	0.96 (NS)

Group 1: general anesthesia; group 2: thoracic epidural anesthesia in combination with light general anesthesia.
NS = nonsignificant.
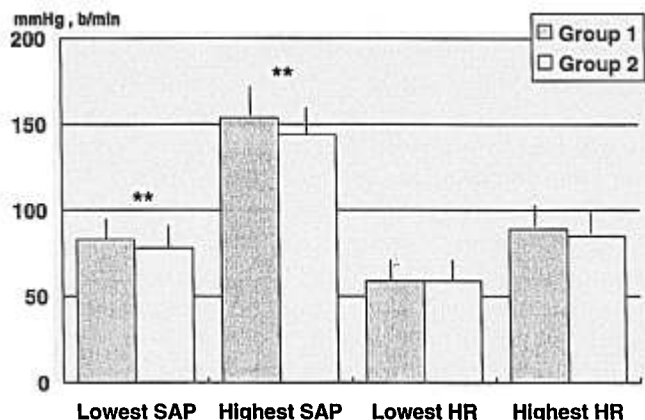* P < 0.05 between groups.

FIG. 1. Intraoperative maximal hemodynamic changes. Group 1: General anesthesia; group 2: thoracic epidural anesthesia in combination with light general anesthesia. **$P < 0.01$ between groups.

TABLE 4. Mortality and Major Postoperative Morbidity

	Group 1	Group 2	P
Mortality	4	3	0.93 (NS)
Cardiac complications*	22	19	0.89 (NS)
Myocardial infarction	5	5	0.82 (NS)
Congestive heart failure	7	5	0.83 (NS)
Prolonged myocardial ischemia	16	16	1.00 (NS)
Ventricular tacchyarrhythmia	0	1	0.98 (NS)
Respiratory complications*	52	45	0.63 (NS)
Atelectasis minor	35	35	0.86 (NS)
Atelectasis major	2	5	0.39 (NS)
Pneumonia suspected	15	11	0.63 (NS)
Pneumonia confirmed	16	8	0.16 (NS)
Acute respiratory failure	8	4	0.42 (NS)
Renal failure	2	4	0.62 (NS)
Gastrointestinal bleeding	0	3	0.22 (NS)
General sepsis	4	2	0.73 (NS)
Major surgical complications	9	6	0.67 (NS)

Group 1: general anesthesia; group 2: thoracic epidural anesthesia in combination with light general anesthesia.

NS = nonsignificant.

* Number of patients who developed at least one cardiac or respiratory complication.

± 4.3 *vs.* 9.2 ± 2.2 mg, $P < 0.001$). The duration of anesthesia was not significantly different between the two groups, whereas intubation times were significantly longer in group 1 than in group 2 (fig. 2).

CLINICAL OUTCOME ANALYSIS

Cardiovascular morbidity (table 4) did not differ between the two groups: 22 patients in group 1 and 19 patients in group 2 had a major postoperative cardiac event. Myocardial infarction was diagnosed in 5 patients in each group, congestive heart failure in 7 patients in group 1 and 5 in group 2, and prolonged myocardial ischemia in 16 patients in each group. Respiratory morbidity (table 4) was extremely frequent (61% in group 1 and 55% in group 2) and not significantly different between the two groups. The most important part of this respiratory mor-

bidity consisted of minor atelectasis. No significant difference in the components of respiratory morbidity was observed between the two groups.

Other major postoperative complications are shown in table 4; no significant difference is observed between the two groups. Among the 6 patients excluded in group 2, 3 developed prolonged myocardial ischemia and 4 minor atelectasis. Even if these patients' data were maintained in the analysis, no significant difference in the cardiac and respiratory complications rate would be observed between the two groups. Four patients in group 1 and 3 patients in group 2 died. Five of them developed a major cardiac complication and six of them a major surgical complication.

Discussion

The major finding of this study is that thoracic epidural anesthesia combined with light general anesthesia offers no major advantage or disadvantage compared to general anesthesia in patients undergoing abdominal aortic surgery. These results do not exclude the possibility that postoperative epidural analgesia exerts a beneficial influence on cardiac and respiratory morbidity during the postoperative period.

METHODOLOGIC BIAS

A primary concern when interpreting the results of a randomized trial is the number of patients studied. The commonest difficulty with small trials is the diminished possibility of detecting differences between treatment groups. The number of patients included in our study
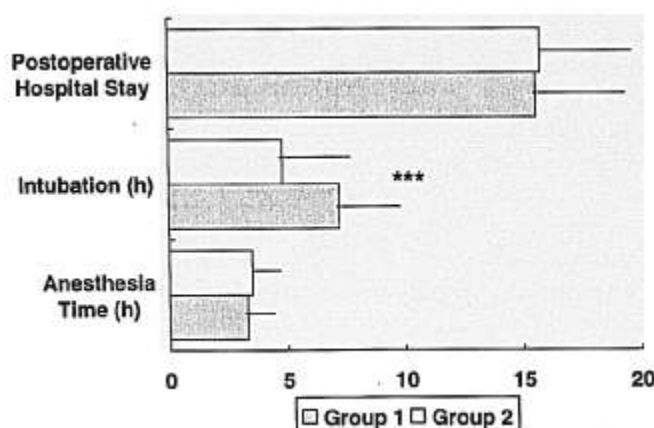

FIG. 2. Durations of anesthesia and intubation and of postoperative hospital stay. Group 1: general anesthesia; group 2: thoracic epidural anesthesia in combination with light general anesthesia ***$P < 0.001$ between groups.

was calculated from a known incidence of cardiac and respiratory complication rate. Accordingly, this number of patients was appropriate to compare the overall incidence of cardiac or respiratory complications. Comments must be restricted to these general complications; no conclusions regarding the details of each can be made.

The primary goal of randomization is to provide a control group. Generally, randomization will provide comparable groups. Yet, when multiplying the number of items, it is understandable that some differences between the groups will emerge. For example, it is possible that despite randomization, one group included patients more ill than those in the other group. However, preoperative work-up, including dipyridamole thallium gammatomography, radionuclide angiography, functional respiratory tests did not show any difference between the two groups.

A second important concern is whether the control group is representative of standard practice. Preoperative cardiac and respiratory evaluation, general anesthesia technique, invasive monitoring (including ST-segment analysis and the use of a pulmonary artery catheter), and postoperative care have been the standard practice of the Vascular Surgery Department of La Pitié-Salpétrière Hospital since 1986. Thus, group 1 could be considered a real control group corresponding to our standard practice. However, only one technique of general anesthesia was compared to thoracic epidural anesthesia combined with light general anesthesia. Accordingly, our results could not be generalized to other anesthetic techniques.

In our study, the inclusion criteria were limited to abdominal aortic surgery. Although this strategy does not permit a generalization of the results, it has some advantages. Such a population is perfectly characterized with respect to the preoperative cardiorespiratory status and to rate of complications. The characteristics of the patients studied were very similar to those of previous reports in age, sex ratio, history of coronary artery disease or congestive heart failure, hypertension, and cardiovascular treatment.[12-15] The findings of dipyridamole thallium gammatomography and postoperative mortality and morbidity were comparable to those of previously published studies.[12-15] Regarding clinical and x-ray abnormalities, a rate of pulmonary complications reaching 55–65% is reported by several studies.[16,17]

THORACIC EPIDURAL ANESTHESIA AND CARDIAC AND RESPIRATORY FUNCTIONS

When referring to the potential beneficial effects described with thoracic epidural anesthesia on myocardial oxygen balance and respiratory function, the absence of improvement of postoperative outcome in the group receiving thoracic epidural anesthesia is surprising. Accordingly, the beneficial effects of thoracic epidural anesthesia

must be reexamined with consideration of the effects of the associated light general anesthesia.

Several experimental studies have demonstrated that thoracic epidural anesthesia could improve myocardial oxygen balance and decrease the incidence of ventricular arrhythmias during acute myocardial ischemia.[18-21] In patients with coronary artery disease, the beneficial effects of thoracic epidural anesthesia have been documented by several studies.[22-25] These beneficial effects result partially from a decrease in the determinants of myocardial oxygen consumption.[23] In addition, it has been shown recently that thoracic epidural anesthesia might increase the diameter of stenotic segments of epicardial coronary arteries.[24] Because these beneficial effects have been demonstrated when small doses of local anesthetics are used to induce a selective cardiac sympathetic blockade with limited hemodynamic effects, however, these results cannot be extrapolated to patients receiving thoracic epidural anesthesia combined with light general anesthesia. Indeed, during abdominal surgery, larger doses of local anesthetics are necessary to extend caudally the epidural blockade, and light general anesthesia with mechanical ventilation is added to the epidural blockade. Such an anesthetic technique induces a substantial hypotension that results mainly from a decrease in venous return.[26] In this context, epidural anesthesia could decrease coronary blood flow[27] and promote myocardial ischemia.

Left ventricular function during thoracic epidural anesthesia may be impaired by different mechanisms: a decrease in preload related to venodilatation,[28] impairment in cardiac contractility resulting from cardiac sympathetcetomy,[29,30] a decrease in heart rate resulting from either decreased sympathetic tone or increased vagal tone,[31] or myocardial ischemia as a consequence of a decrease in arterial perfusion pressure. On the other hand, several mechanisms may contribute to improving left ventricular function during this anesthetic procedure: these include a decrease in afterload due to the reduction in systemic vascular resistance,[22] cardiac effects of local anesthetics agents,[32,33] and use of direct or indirect sympathomimetic drugs.[34,35] Alteration of left ventricular function during thoracic epidural anesthesia with general anesthesia results from the effects of these opposing factors and may be either improved or impaired depending on which predominates.

Respiratory complications result from the pattern of restriction as well as ventilation–perfusion abnormalities induced by upper abdominal surgery.[16,17] Diaphragmatic dysfunction is probably the mechanism responsible for these impairments.[36] Thoracic epidural analgesia may partially or totally reverse this dysfunction.[36] The intraoperative anesthetic technique probably has no influence on these intraoperative induced abnormalities, since both groups of patients received general anesthesia, mechanical

ventilation, and identical surgical procedure. The only factor that may favorably influence the rate of respiratory complications could be the shorter duration of mechanical ventilation, since patients with epidural anesthesia did not receive opioids to maintain anesthesia. In our study this difference is significant but is limited to 2 h. Clearly, with regard to respiratory complications, no significant advantages are to be expected from the intraoperative technique.

POSTOPERATIVE ANALGESIA

Several studies have compared epidural and parenteral analgesia.[3,4,8-9,37-40] Among these studies, only two included a large number of patients[8,9] and only a few demonstrated the superiority of epidural anesthesia.[4,40] Two reports have shown the beneficial effects of epidural analgesia compared with parenteral morphine,[1,40] as has a major study from Yeager and co-workers.[6] When compared to a group of patients who received general anesthesia, patients in the latter study who received epidural analgesia were found to have a reduction in postoperative mortality, overall postoperative complication rate, and incidence of cardiovascular failure and major infections. These authors[6] concluded that epidural anesthesia and postoperative care including epidural analgesia provided with opioids and/or local anesthetic could be the factors that determine ultimate morbidity and mortality.

Our study, which focuses on intraoperative technique, does not demonstrate that thoracic epidural anesthesia combined with light general anesthesia influences major cardiac and respiratory morbidity after abdominal aortic surgery. The postoperative protocol for analgesia was not directed by the study protocol. Three different analgesic techniques were distributed equally in both groups. This difference between our study and that of Yeager et al.[6] in the strategy used for postoperative analgesia could suggest that postoperative epidural analgesia, rather than epidural anesthesia, plays a major role in the decrease in postoperative complications. There are two main reasons for not analyzing our data according to the analgesic technique. First, postoperative analgesia was not randomized. Second, the sample size of the study is not large enough to compare the three techniques used in our study. In addition, we cannot analyze together patients who received epidural analgesia with opioids and/or local anesthetic. Indeed, the effects of epidural analgesia with local anesthetic on cardiac and respiratory functions are different from those of epidural analgesia with opioids. Diaphragmatic dysfunction after upper abdominal surgery is reversed by epidural analgesia[36] with local anesthetic and is not influenced by epidural analgesia with opioids.[41] Beneficial effects of epidural analgesia on myocardial oxygen balance seem to be directly related to the cardiac sympathetic blockade induced by local anesthetics.[23-25]

Despite these limitations, regarding our results and those of Yeager et al.[6] we suggest that postoperative epidural analgesia rather than intraoperative epidural anesthesia is an important determinant in preventing postoperative cardiac and respiratory complications.

This randomized study was designed to determine in patients scheduled for abdominal aortic surgery whether intraoperative thoracic epidural anesthesia combined with light general anesthesia alters postoperative morbidity when compared to a standard technique of "balanced" general anesthesia. The number of patients to be included in the study was prospectively established from a known incidence of postoperative complications associated with this type of surgery. The major finding of this study is that thoracic epidural anesthesia combined with light general anesthesia in patients undergoing abdominal aortic surgery offers no major advantages or disadvantages when compared to general anesthesia. Regarding studies that showed that epidural anesthesia and analgesia favorably influence postoperative outcome, we suggest that postoperative epidural analgesia rather than intraoperative epidural anesthesia is the factor preventing or reducing the incidence of postoperative cardiac and respiratory complications.

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