VIA MEDICA

ORIGINAL AND CLINICAL ARTICLES

Anaesthesiology Intensive Therapy
2015, vol. 47, no 4, 291–296
ISSN 1642–5758
10.5603/AIT.2015.0043
www.ait.viamedica.pl

Does epidural anaesthesia reduce the incidence of postoperative oxygen desaturation episodes in patients undergoing open abdominal aortic aneurysm repair?

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Abstract

Background: Postoperative desaturation can lead to severe hypoxaemia and even tissue hypoxia, followed by cardiological and neurological complications. Opioid usage is the one of the most important risk factors of postoperative desaturation and hypoxemia. Epidural anaesthesia is recommended for vascular surgery for many reasons; the reduction or elimination of opioid doses is one reason. The aims of the study were to evaluate the incidence of desaturation episodes in patients after surgical procedures with abdominal aortic clamping, to determine whether the episodes in question lead to clinical symptoms of hypoxia and to determine whether epidural anaesthesia decreases the incidence of desaturation episodes.

Methods: After abdominal aortic repair, 58 patients who did not have any respiratory disease, were classified as ASA II–III, and were aged from 46 to 80 years were observed in the ICU during spontaneous breathing with oxygen supplementation. Non-invasive O_2 saturation measurements were taken continuously, and all desaturation incidents (defined as O_2 saturation ≤ 93% for 4 min) were noted. Patients were divided into two equal groups: A — epidural blockade used after the operation for pain relief and B — intravenous opioids administered during the postoperative period. We evaluated and compared the desaturation frequency during the postoperative period.

Results: Desaturation was observed among 26 (89%) patients in group A and 27 (93%) patients in group B. There were no statistical differences among the groups ($P = 1.0$). Severe hypoxemia (O_2 saturation ≤ 84%) was observed among 7 (24.1%) patients in group A and 10 patients in group B (34.5%) ($P = 0.38$). Clinical symptoms of hypoxia were similar in both groups ($P = 1.0$).

Conclusions: Epidural anaesthesia did not protect against postoperative desaturation. Though oxygen therapy was used, desaturation was observed in approximately 90% of patients.

Key words: abdominal aorta surgery, epidural blockade, postoperative period, complications, hypoxia, desaturation

Anaesthesiology Intensive Therapy 2015, vol. 47, no 4, 291–296

Surgical procedures involving the aorta and peripheral vessels belong to the highest-risk group for cardiovascular complications; advanced age and concomitant diseases are additional factors increasing this risk [1, 2]. According to many authors, surgical treatment outcomes in this group of patients increasingly depend on surgery preparation and the quality of postoperative care [1–4]. Therefore, some centres admit patients to the intensive care units prior to surgery to evaluate and optimize cardiovascular functions in order to prepare them for surgery [1–6]. Similarly, this group requires continuous postoperative monitoring and homeostatic imbalance correction, frequently resulting from the specificity of the surgery, including ischaemia-reperfusion syndrome [5–7].

Postoperative hypoxia is the factor that increases the risk of perioperative complications; its consequences predominantly affect the central nervous system (CNS) and the cardiovascular system (CVS) [8–10]. The development of complications is particularly dangerous for individuals

with a history of cardiovascular diseases, i.e., the group that constitutes the majority of patients who are qualified for vascular procedures [1–4, 9, 11–12]. In the postoperative period, the most likely cause of hypoxia is hypoxaemia; factors such as hypovolaemia or hypotension can enhance hypoxia-associated consequences [9, 12–13].

Extensive vascular procedures are usually performed under general anaesthesia [5]. Because of the risk of hypoxia related to ischaemia-reperfusion syndrome, new methods to limit or alleviate the consequences have been sought. Recently, the advantages of inhalation anaesthesia and epidural blocks have been highlighted. In addition to its other advantages, epidural anaesthesia enables the limitation of the systemic dosage of opioids, which are considered to be one of the causes of postoperative hypoxia [5, 9, 14–17].

Early hypoxaemia observed in the postoperative period is associated directly with anaesthesia and the recovery period. A late hypoxaemia event that occurs 5–7 days after surgery manifests itself in continuous or incidental decreases in partial pressure of oxygen in arterial blood (PaO_2) and arterial haemoglobin oxygen saturation (SaO_2). In the latter case, incidents of reduced PaO_2 or SaO_2 occur primarily at night [10, 16–18].

Desaturation episodes are defined as a decreased arterial haemoglobin oxygen saturation that is measured transdermally below 94% that lasts continuously for at least 4 min [9, 16–19]. The factors considered to determine the extent of desaturation episodes are their duration and the lowest recorded SpO_2 [9, 17, 19].

Postoperative hypoxia is thought to cause tachycardia, cardiac arrhythmias, hyper- and hypotension, ischaemia, myocardial infarction and postoperative confusion as well as impaired healing of wounds and infections [9, 11, 19–21].

The aims of the study were to evaluate the incidence of desaturation episodes in patients after surgical procedures with abdominal aortic clamping, to determine whether the episodes in question lead to clinical symptoms of hypoxia and to determine whether epidural anaesthesia decreases the incidence of desaturation episodes.

METHODS

The study design was approved by the Independent Bioethics Committee of the Medical University of Gdańsk. Written informed consent was obtained from all patients included in the study.

The prospective study encompassed 58 patients of both sexes without respiratory diseases who were aged 45–80 years; patients were ASA II and III and class II, III and IV according to the Lee cardiac risk index. All patients underwent elective procedures with abdominal aortic clamping.

The patients were divided into two groups (A and B) according to the type of anaesthesia that was provided. In group A, general and epidural anaesthesia were used, whereas in group B, only general anaesthesia was administered. Group allocation depended on contraindications for epidural block and patients` preferences. In all patients, anaesthesia was induced with intravenous fentanyl, propofol and vecuronium and was maintained by inhalation of sevoflurane. The following parameters, connected with the course of surgery and the possible effects on the postoperative period, were recorded intraoperatively: the length of surgery and aortic clamping as well as approximate intraoperative blood loss. After surgery, patients were transported to the ICU without awakening in the operating room. The data for analysis were collected from the moment of mechanical ventilation completion to removal of the endotracheal tube. The patients were observed for 72 h of spontaneous breathing with passive oxygen therapy. The postoperative observational period was divided into days, distinguishing day and night hours. SpO_2 was monitored continuously; measurements were recorded every minute. Based on the monitor memory, incidents of desaturation were searched for; desaturation was defined as an SpO_2 of $\leq$ 93% that was incessantly maintained for at least 4 minutes within an hour. Severe hypoxaemia was defined as SpO_2 $\leq$ 84%. The patients were examined on the first, second and third postoperative day in the morning hours; clinical symptoms of hypoxia sequels in the form of CNS and CVS disorders were recorded.

The same postoperative treatment and monitoring protocol was used, except for analgesic therapy, which resulted from the type of anaesthesia. In group A, pain was managed with a continuous infusion of 0.125% bupivacaine into the epidural space, while in group B, intravenous opioids were administered.

Assuming that desaturation incidents occur most commonly during the night hours, nocturnal episodes, i.e., those occurring between 23:00 and 6:59, and day episodes, i.e., those occurring between 7:00 and 22:59, were distinguished. The time between ICU admission and 22.00 hours on the day of the first night of the stay was defined as day zero. Moreover, the hour of spontaneous breathing with desaturation incidents was recorded. Because the time of mechanical ventilation in individual patients and the hours of endotracheal tube removal were different, hours of spontaneous breathing when desaturation was observed were referred to as the time of the day and night as well as the observation day.

STATISTICAL ANALYSIS

Statistical analysis was performed using Statistica 7.1 PL software (StatSoft, Tulsa, USA). The interval data with distributions close to normality (verified with the Shapiro-Wilk test) were compared using the Student's t-test for independ-

ent variables (following verification of homoscedasticity with the Levene`s test); for comparisons of more than two groups, one-way analysis of variance (ANOVA) was applied. When significant intra- and intergroup differences were found, the *post-hoc* Newman-Keulus test was used. The interval data that did not show normality and the ordinal data were compared with the Mann-Whitney U test. The nominal data were compared using the χ^2 Fisher test; the Fisher-Snedecor test was applied in justified cases. $P < 0.05$ was considered to be significant in all analyses.

RESULTS

The comparison of groups according to age, height, body weight, body mass index (BMI), ASA physical status scale rating and the Lee cardiac risk index revealed that the study groups differed only with regard to mean body weight; in group A, mean body weight was 80.2 ± 13.7 kg and was 71.5 ± 13.9 kg in group B ($P = 0.02$ L). In group A, the BMI was 26.6 ± 3.6 kg m^{-2}, and in group B, the BMI was 25.1 ± 3.8 kg m^{-2} ($P = 0.012$). There were no significant differences in the length of surgery, aortic clamping time and intraoperative blood loss.

Incidents of desaturation were observed in 53 patients (91.3%): 26 (89.6%) in group A and 27 (93.1%) in group B ($P = 1.0$). Severe hypoxaemia ($SpO_2 \leq 84\%$) was noted in 7 (24.1%) group A patients and in 10 (34.5%) group B patients ($P = 0.37$). The median duration of desaturation events was 97 minutes in group A and 157 minutes in group B ($P = 0.72$).

The mean number of desaturation episodes during individual observation days in patients with desaturation incidents is presented in Figure 1. The mean durations of desaturation events are illustrated in Figure 2, while the minimum SpO_2 that was measured during desaturation events on individual days is presented in Figure 3.

Significant intragroup differences in the number of desaturation events were observed in group A between day zero and the second postoperative day ($P = 0.0012$) as well as between day zero and the third postoperative day ($P = 0.0013$), and in group B between day zero and the first postoperative day ($P = 0.012$), day zero and the second postoperative night ($P = 0.0102$), and day zero and the second postoperative day ($P = 0.036$). However, no significant intergroup differences were found ($P = 0.944$).

The incidence of day and night desaturation episodes in both groups was similar during the individual observation days. The comparison of the number of day and night desaturation episodes in the entire observation period demonstrated that 273 nocturnal desaturation episodes were observed in group A patients, which constituted 57.2% of all episodes noted in this group; in group B, nocturnal desaturation was observed in 283 cases, which constituted 56.7% of all desaturation events in this group.

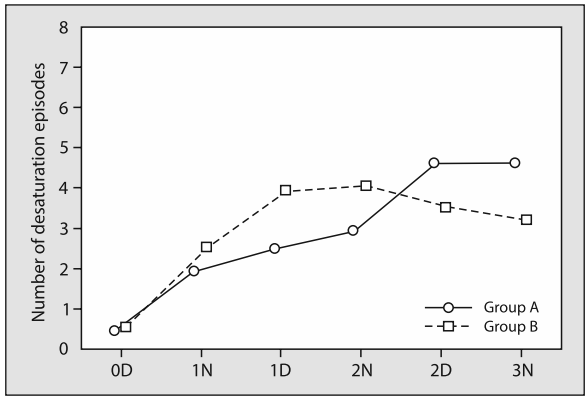

Figure 1. The mean number of desaturation episodes on individual days

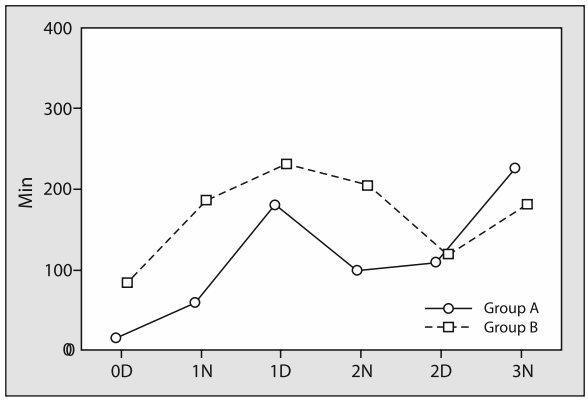

Figure 2. Mean duration of desaturation episodes on individual days

Analysis of the incidence of desaturation episodes during individual hours of spontaneous breathing showed a similar distribution in both groups.

The incidence of desaturation episodes according to the hours of spontaneous breathing is presented in Figure 4.

There were no intergroup differences in the incidence of clinical symptoms of hypoxia, i.e., cognitive disorders and/or psychomotor agitation, tachycardia, atrial fibrillation, other arrhythmias, or myocardial infarction. Table 1 presents the number of patients with clinical symptoms of hypoxia according to individual days of observation.

DISCUSSION

In our opinion, treatment outcomes in patients undergoing vascular surgical procedures are determined by the postoperative period course [1, 3–5, 7]. It seems that monitoring of patients and increased surveillance only in the immediate postoperative period are insufficient. In many centres worldwide, patients are transferred after surgery to post-anaesthesia care units (PACUs) [1, 3–5, 7]. In Poland, this system functions only in a few hospitals, and patients

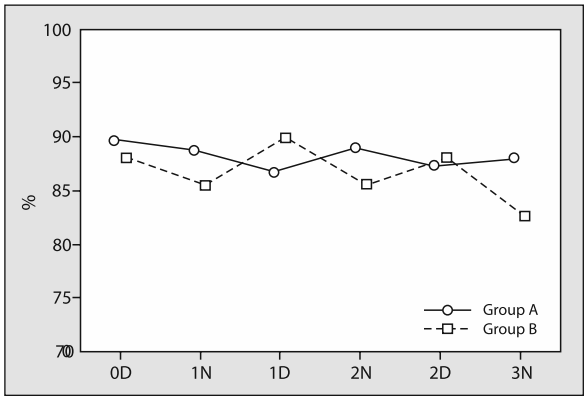

Figure 3. Mean minimum saturation measured during desaturation episodes on individual days

are most commonly transferred immediately after surgery to post-anaesthesia care units. However, such units seldom provide 24-hour services, which limits the patients` stay to several hours after surgery; thus, the symptoms of organ failure are likely to be unnoticed.

In the 80s and 90s of the previous century, with the popularisation of transdermal pulse oximetry, attention was drawn to the issue of postoperative hypoxia [10–13, 16–19]. The first papers were observational and were carried out in patients who were not treated with oxygen postoperatively [18, 20]. At present, the postoperative period is one of the major indications for oxygen therapy; thus, studies evaluating the incidence of hypoxia episodes in patients who were not treated with oxygen are incidental.

Based on a study in PACU patients, Moller [18] evaluated the incidence of desaturation events and their severity and noted that postoperative hypoxia is a common phenomenon and that oxygen therapy does not protect against hypoxaemia events, which was consistent with the conclusions that were reported by Rosenberg [13] and Russell [12]. Similarly, episodes of hypoxaemia in our study group were common and comprised 90% of patients in both groups. Although in some patients hypoxaemia episodes were single events, the remaining patients developed them multiple times during the observation period. Use of oxygen therapy did not protect against desaturation episodes but contributed to increases in PaO_2 and SaO_2; this result was also reported by Rosenberg and Pedersen. In the study performed by Reeder [16] amongst patients after vascular procedures receiving oxygen therapy, there were no desaturation events during the 5 days of its use; however, immediately after its discontinuation, the episodes with SpO_2 below 85% developed in 50% of patients. In the majority of studies, desaturation is assumed to be the level of saturation below or equal 93%, while Reeder recorded desaturation episodes only at values below 90%; this difference can explain the discrepancy between his results and those reported by other authors [22–25], including our findings.

Besides the very fact of occurrence of desaturation, its severity is essential, which is characterized by the duration of episodes and minimum SpO_2 recorded. In the studies mentioned above, desaturation was diagnosed comparing the percentage drop in SpO_2 in relation to the baseline value, i.e., before surgery, or assuming a decrease in SpO_2 < 94% for at least 4 minutes continuously during one hour. An SpO_2 of < 90% is defined as an incident of hypoxaemia. In the majority of studies, an SpO_2 of < 85% is considered to be severe hypoxaemia, which is tantamount with hypoxic hypoxia, while multiple desaturation incidents are classified as hypoxia incidents [9–10, 13, 16–20]. There is no consensus as to the time that decreased SpO_2 should be maintained in order to consider it as desaturation. The time range is 2–5 minutes according to different studies [9–10, 13, 16–20, 24]. In our material, the lowest SpO_2 during desaturation episodes was 73% in group A and 70% in group B; the lowest SpO_2 allowed for the diagnosis of hypoxaemia, whereas the shortest mean duration of an episode in both groups was comparable, i.e., 6 minutes. Such deep and long-term hypoxaemia can be the cause of hypoxia, including myocardial hypoxia.

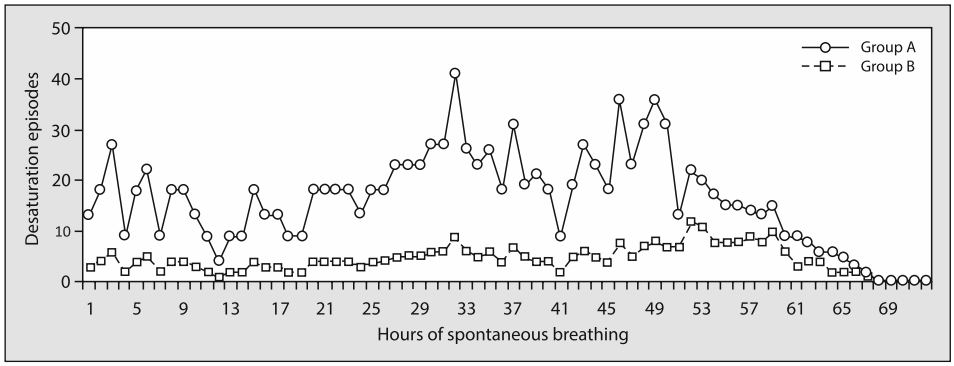

Figure 4. Incidence of desaturation episodes in individual hours of spontaneous breathing

Table 1. Number of patients with hypoxic symptoms in group A and B on individual days

	Day 1		Day 2		Day 3	
Group	**A**	**B**	**A**	**B**	**A**	**B**
Cognitive and/or psychomotor disorders	1	0	0	0	4	1
Tachycardia	0	0	1	0	0	2
Atrial fibrillation	0	2	0	2	0	4
Myocardial infection	0	0	1	0	0	2
Cardiac arrhythmias	0	0	1	1	0	2

In the entire group of patients, the number of desaturation episodes increased during successive observation periods. In patients receiving postoperative opioids, the highest number was observed during the second postoperative night and tended to decrease. In patients receiving analgesic treatment using an epidural catheter, i.e., those who did not receive opioids, the highest number of hypoxaemia occurrences was found on the second postoperative day when their number reached a plateau and remained at the same level until the end of observation. In both groups, the number of nocturnal incidents was higher than day incidents, constituting 57% of all incidents noted; however, the difference was not as significant as the one reported by Rosenberg [10, 11, 13].

Moreover, in both groups, the number of desaturation episodes was found to increase between hours 20–24 of spontaneous breathing, with another peak between 55–60 hours of observation, showing the tendency to decrease. After 70 hours, no incidents of hypoxaemia were observed in any patient. The above results confirm the observations of Rosenberg [10, 11], Pedersen [13] and Reeder [12], which indicate that postoperative hypoxaemia does not have to include the immediate postoperative period and can develop later, even up to 7 days after surgery, according to some authors [9, 10, 13, 16]. Lower incidences of hypoxaemia in the immediate postoperative period are likely to result from favourable effects of mechanical ventilation, lung expansion and the use of concentrations of a respiratory mixture of oxygen higher than 21%. In the successive hours of spontaneous breathing, ventilation and gas exchange deteriorate because of hypoventilation and impaired physiological mechanisms protecting against hypoxaemia [16–18, 22–24].

Patients in both groups were treated and monitored according to the same protocol; the only factor distinguishing the groups was the mode of analgesic therapy that resulted from the kind of anaesthesia used. Because desaturation incidents occurred in both study groups in the same periods of spontaneous breathing and with a similar frequency, it seems that their occurrence is not associated with opioids, the administration of which is considered to be the risk factor for developing postoperative hypoxaemia [5, 9, 10, 17]. Therefore, it cannot be explicitly recognised that epidural anaesthesia reduces the incidence of hypoxaemia episodes.

The risk factors of postoperative hypoxia also include age, female gender and obesity [9, 10, 12, 13, 16–18]. The patients in both groups did not differ according to age or percentages of women. The group A patients were characterised by a significantly higher body weight and a higher BMI; nevertheless, the incidence of desaturation episodes in this group was similar to that in group B. Moreover, a higher body weight was not found to be associated with a higher incidence of desaturation episodes; however, it should be emphasised that patients with greater weight did not receive opioids, and many authors associate their use with postoperative hypoxia in obese patients.

Furthermore, in addition to the incidence of postoperative hypoxaemia, its consequences are crucial [9–13, 16–24]. Patients undergoing vascular procedures most commonly develop postoperative cardiac complications in the form of hypo- or hypertension, cardiac arrhythmias, circulatory failure or myocardial infarction; postoperative hypoxaemia is an additional factor that enhances the symptoms and deterioration prognosis [3, 7, 8, 9, 18, 20].

One of the factors increasing the risk of myocardial hypoxia is perioperative tachycardia, which can be caused by insufficient analgesic treatment [21, 23]. In our population, the peak pain severity was observed during the first postoperative day, while tachycardia was noted on the second and third day when the incidence of desaturation episodes and their duration was increasing.

Atrial fibrillation occurred in all patients who had been diagnosed with paroxysmal atrial fibrillation earlier and in 5 patients without a history of paroxysmal atrial fibrillation. On the successive days of observation, atrial fibrillation occurred in almost 14% of patients; although no significant intergroup differences were observed in the incidence during the successive days, no cases of paroxysmal atrial fibrillation were noted in group A throughout the observation period. Global analysis of the incidence of atrial fibrillation during ICU hospitalisation rather than on successive observation days could demonstrate such a difference. Moreover, arrhythmias other than sinus tachycardia and paroxysmal atrial fibrillation were also observed, but their incidence was the same in group A and B.

The most severe cardiac complication is considered to be perioperative myocardial infarction. In the postoperative period during the observation of ICU patients, myocardial infarction was diagnosed in three patients (5%): one from group A and two from group B. Although some authors have reported that epidural anaesthesia reduced the risk of myocardial hypoxia [8, 16], the majority have not confirmed such effects [4, 6, 12, 17], which is consistent with our findings.

In addition to cardiac complications, after vascular procedures, patients are at risk of neurologic complications and transient CNS dysfunction [7, 9, 12, 21–25]. The incidence of postoperative confusion in our population was found to be substantially higher on the third postoperative day. Desaturation episodes were observed in all patients with consciousness disorders. Though no significant intergroup differences were noted, five of six patients with consciousness disorders were anaesthetised using epidural blocks.

Furthermore, it was observed that postoperative confusion occurred in all patients who had developed them after previous surgical procedures, most commonly after cardiac procedures.

Our study findings demonstrate that the episodes of hypoxaemia in the postoperative period are common and are accompanied by clinical symptoms of hypoxia. Therefore, in the postoperative period, patients should be monitored for longer than several hours or 24 h after surgery, irrespective of the anaesthesia used. The incidence of hypoxia episodes occurring despite the type of passive oxygen therapy that was administered indicates that its use in the postoperative period is absolutely necessary. The lack of protective effects of epidural anaesthesia on the incidence of postoperative desaturation episodes is disappointing.

CONCLUSIONS

Episodes of hypoxaemia observed during the postoperative period are common. These episodes occur irrespective of the kind of anaesthesia provided and can lead to clinical symptoms of hypoxia, predominantly in the CNS and CVS.

Epidural anaesthesia was not related to the expected decrease in the incidence of hypoxaemia episodes in the postoperative period and did not reduce the frequency of cardiologic complications.

ACKNOWLEDGEMENTS

1. The authors declare no financial disclosure.
2. The authors declare no conflict of interest.

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Received: 8.10.2014
Accepted: 1.04.2015