The Effects of Thoracic Epidural Anesthesia on Hepatic Blood Flow in Patients Under General Anesthesia

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BACKGROUND: Hepatic hypoperfusion is regarded as an important factor in the pathophysiology of perioperative liver injury. Although epidural anesthesia (EDA) is a widely used technique, no data are available about the effects on hepatic blood flow of thoracic EDA with blockade restricted to thoracic segments in humans.

METHODS: In 20 patients under general anesthesia, we assessed hepatic blood flow index in the right and middle hepatic vein by use of multiplane transesophageal echocardiography before and after induction of EDA. The epidural catheter was inserted at TH7-9, and mepivacaine 1% with a median (range) dose of 10 (8–16) mL was injected. Norepinephrine (NE) was continuously administered to patients who demonstrated a decrease in mean arterial blood pressure below 60 mm Hg after induction of EDA (EDA-NE group). The other patients did not receive any catecholamine during the study period (EDA group). A further 10 patients without EDA served as controls (control group).

RESULTS: In five patients, administration of NE was necessary to avoid a decrease in mean arterial blood pressure below 60 mm Hg. Thus, the EDA-NE group consisted of five patients and the EDA group of 15. In the EDA group, EDA was associated with a median decrease in hepatic blood flow index of 24% in both hepatic veins ($P < 0.01$). In the EDA-NE group, all five patients showed a decrease in the blood flow index of the right (median decrease 39 [11–45] %) and middle hepatic vein (median decrease 32 [7–49] %). Patients in the control group showed a constant blood flow index in both hepatic veins. Reduction in blood flow index in the EDA group and the EDA-NE group was significant in comparison with the control group ($P < 0.05$). In contrast to hepatic blood flow, cardiac output was not affected by EDA.

CONCLUSIONS: We conclude that, in humans, thoracic EDA is associated with a decrease in hepatic blood flow. Thoracic EDA combined with continuous infusion of NE seems to result in a further decrease in hepatic blood flow.

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Hepatic hypoperfusion is regarded as an important factor in the pathophysiology of perioperative liver injury.[1] Furthermore, it has been hypothesized that hypoperfusion of the liver may initiate or contribute to the development of a systemic inflammatory response syndrome that may lead to multiple organ failure.[2]

Thoracic epidural anesthesia (EDA) and analgesia with local anesthetics is a widely used technique for intraoperative and postoperative pain control in major surgery. However, EDA may induce different physiological reactions with conflicting effects on hepatic blood flow. For example, blockade of thoracic efferent sympathetic fibers causes regional arteriolar dilation, and thus increases regional blood flow. On the other hand, hypotension as a result of a decreased systemic vascular resistance may reduce hepatic blood flow. Lumbar and high lumbar EDA has been shown to induce a decrease in hepatic blood flow in animals[3,4] and in humans.[5,6] In contrast to these studies, Vagts et al.,[7] using a pig model, did not observe alterations in total hepatic blood flow after induction of thoracic EDA, despite a significant decrease in systemic arterial blood pressure. Thus, we hypothesized that thoracic EDA maintains hepatic blood flow also in humans.

The main objective of the present study was to investigate the effects of thoracic EDA on hepatic blood flow in humans. In addition, because vasopressor therapy is commonly used to treat EDA-induced hypotension,[8] the secondary objective of the study was to investigate the effects of norepinephrine (NE) in patients with marked EDA-induced arterial hypotension.

METHODS

This study was designed with the aim to enroll 30 patients consecutively, 20 patients with EDA and 10 patients without EDA (control group). The control group consisted of patients with contraindications for

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EDA, in whom insertion of the epidural catheter was not possible or the desired sensory blockade could not be achieved. All patients were scheduled for major pancreatic surgery.

Exclusion criteria were atrial fibrillation or any other known cardiovascular disease and contraindications to transesophageal echocardiography (TEE), such as diseases of the esophagus or stomach. The study was approved by the ethics committee of the University Ulm. Written informed consent was obtained from all patients before inclusion in the study.

EDA and General Anesthesia

The thoracic epidural catheter was inserted the evening before surgery. It was introduced at the level of TH7/8 or TH8/9 and was advanced 5–8 cm into the epidural space. Subsequently, 5 mL mepivacaine 1% was administered. Provided there was no spinal anesthesia, administration of 3–5 mL mepivacaine was repeated.

After a time interval of 30 min, sensory blockade was tested by pinprick. The end result was segmental blockade of levels TH4–TH11. In case the desired block level was not achieved, administration of 3 mL mepivacaine 1% was repeated and after 30 min sensory blockade was reevaluated. If a fourth administration of 3 mL mepivacaine 1% did not lead to the desired extent of the sensory blockade, the patient was excluded from the EDA group and served as a control patient the next day.

All patients received oral benzodiazepine premedication with clorazepate dipotassium (20 mg) in the evening and midazolam (7.5 mg) 1 h before induction of general anesthesia. After a standardized induction with propofol (2–3 mg/kg), fentanyl (2–4 μg/kg), and rocuronium (0.5 mg/kg), the patient's trachea was intubated and mechanical ventilation inititated. Anesthesia was maintained with desflurane and fentanyl as required. A radial arterial line, an internal jugular central venous catheter and a multiplane TEE probe (Omniplane I, Hewlett-Packard, Andover, MA) were then inserted. The TEE probe was connected to the Hewlett Packard Sonos 5500 echocardiograph.

Study Protocol

After induction of general anesthesia, insertion of the catheters and TEE probe, baseline measurements of cardiac output and blood flow in the right and middle hepatic vein were performed and completed by registration of heart rate (HR), mean arterial blood pressure (MAP), central venous pressure, end-tidal CO_2 partial pressure, end-tidal desflurane concentration, applied dosage of fentanyl, and amount of administered fluids. Before baseline measurements, all patients received at least 500 mL crystalloids and 500 mL hydroxyethylstarch 6% (Voluven®). Depending on the MAP, further fluids were administered with the aim to maintain MAP above 60 mm Hg.

After baseline measurements, mepivacaine 1% was injected into the epidural catheter by using the volume that had been determined the evening before to obtain the desired sensory blockade from TH4 to TH11. Fluid administration was continued with approximately 5 $mL \cdot kg^{-1} \cdot h^{-1}$, but, depending on the MAP, the infusion rate could be increased again with an aim for maintaining MAP above 60 mm Hg. Thirty minutes after injection of the local anesthetic, measurements of cardiac output, blood flow in the right and middle hepatic vein, and registration of the above-mentioned variables were repeated.

If MAP decreased below 60 mm Hg within a period of 20 min after injection of mepivacaine, NE was continuously administered with an initial dosage of 0.05 $\mu g \cdot kg^{-1} \cdot min^{-1}$. If required, the dosage was adjusted by 0.1–0.3 $\mu g \cdot kg^{-1} \cdot min^{-1}$ until MAP was at least 75 mm Hg. Before the intervention measurement was performed, a stable blood pressure under constant NE administration for at least 5–10 min was required. Patients who received NE were separately analyzed as the EDA-NE subgroup (EDA-NE group).

All measurements were performed before surgery. The function of the epidural catheter was checked by pinprick evaluation of sensory blockade on the first postoperative day in all patients.

Assessment of Hepatic Blood Flow

Blood flow of the right and middle hepatic vein was assessed by multiplane TEE as previously described.[9–13] Briefly, for visualization of the hepatic veins, the tip of the probe was advanced into the antrum of the stomach and flexed anteriorly. The Doppler signal was attained by pulsed wave Doppler technique (PW-mode). The sample volume was placed in the center of the vessel at exactly the location used for measuring the diameter. Correction of the angle between the Doppler beam and the flow axis was performed for each Doppler measurement. Both the vessel diameter and the Doppler signal were obtained during a short phase of apnea induced by disconnection of the tracheal tube from the respirator. Blood flow in the right and middle hepatic vein was calculated using the formula:

$$\text{Blood flow} = k \cdot \text{VTI} \cdot \pi \cdot r^2 \cdot \text{HR}$$

(VTI, time velocity integral; πr^2, cross-sectional area of the vessel, HR, $k = 0.7$).[14,15] VTI is the area under the Doppler curve over one cardiac cycle. The correction factor k is derived from an experimental study in pigs and considers that the blood flow is not flat but has a parabolic velocity profile.[12,13]

In addition, the blood volume that travels during one cardiac cycle within the hepatic vein (stroke $\text{volume}_{\text{hepatic vein}}$) was calculated as:

$$\text{Stroke volume}_{\text{hepatic vein}} = k \cdot \text{VTI} \cdot \pi \cdot r^2$$

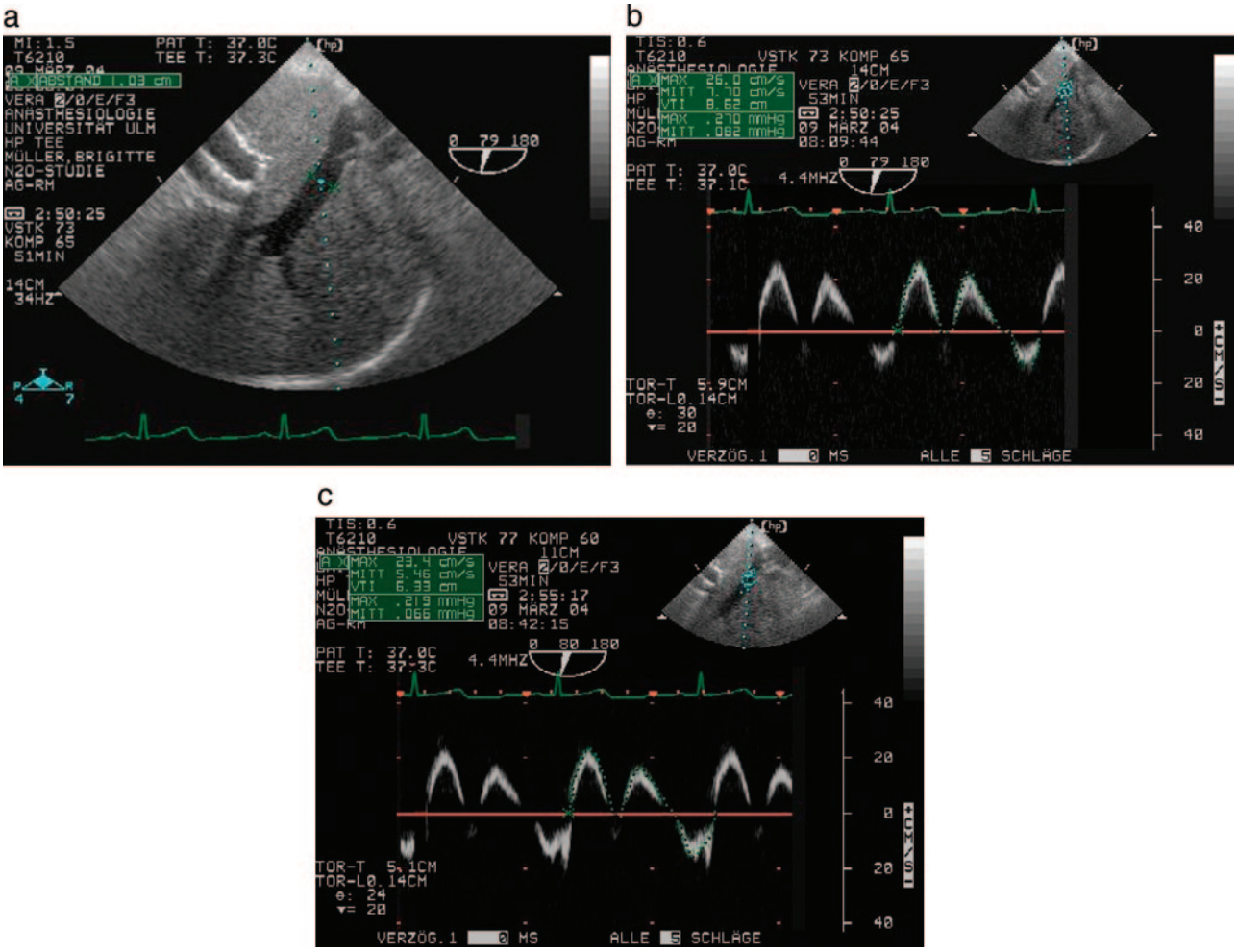

Figure 1. Example for hepatic blood flow decrease in the middle hepatic vein after induction of epidural anesthesia in a 49-yr-old patient. Two-dimensional picture of the middle hepatic vein before epidural anesthesia (a). The diameter of the middle hepatic remained unchanged after induction of epidural anesthesia (no picture). Doppler tracings of the blood flow before (b) and 30 min after (c) induction of epidural anesthesia. The velocity time integral (area under the Doppler curve) decreased from 8.6 to 6.3 cm, the heart rate was constant with 53 bpm. The calculated blood flow decreased from 266 to 195 mL/min.

Blood flow index and stroke volume index of the right and middle hepatic vein were calculated by dividing the hepatic blood flow and stroke volume, respectively, by the body surface area.

All measurements were analyzed off-line by using the HP Sonos 5500 ultrasound system software. HR was derived from the electrocardiogram on the Doppler image. Hepatic vein diameters were measured according to the leading-edge to leading-edge method. Measurements were performed in triplicate and averaged. The VTI was determined by manual tracing of the outer shape of the Doppler curve over one cardiac cycle as shown in Figures 1b and c and calculated by using the integrated software of the echocardiograph. This approach implies that the atrial contraction-induced end-diastolic reverse flow is subtracted from the sum of the systolic and diastolic forward flow. Three cardiac cycles were evaluated and averaged. All Doppler curves were evaluated by the same observer who was blinded regarding the group and time of measurement.

Assessment of Cardiac Output

Assessment of cardiac output was performed by TEE as described by Perrino et al.[16] Aortic valve area was plain metered using the triangular method proposed by Darmon et al.[17] Measurements of the aortic valve area were performed in triplicate and averaged. As the main objective was to determine changes in cardiac output, we decided to use the result of these initial aortic valve area measurements for the baseline and the subsequent cardiac output calculation. Aortic blood flow velocities were obtained by a continuous wave Doppler beam focused at the level of the aortic valve during a short phase of apnea. Three Doppler images were stored on a magneto-optical disk. One velocity waveform on each image was measured by planimetry to generate the VTI. The average of the three VTI measurements was used to calculate cardiac output. Cardiac output was calculated off-line as the product of VTI, aortic valve area, and HR. All measurements were performed by the same blinded person who analyzed the hepatic blood flow curves.

Table 1. Patient Characteristics

	EDA group (n = 15)	EDA-NE group (n = 5)	Control group (n = 10)
Sex (f/m)	1/14	2/3	7/3
Age (yr)	60 (48–75)	66 (41–79)	61 (40–72)
Body height (cm)	176 (159–182)	166 (160–180)	167 (158–175)
Body mass (kg)	80 (53–108)	68 (65–75)	81 (49–108)
Body surface area (m^2)	1.96 (1.56–2.29)	1.76 (1.72–1.94)	1.89 (1.48–2.22)
ASA-classification II (%)	47	40	30
ASA-classification III (%)	53	60	70
History of hypertension (%)	53	20	50
Coronary artery disease (%)	20	20	20
Surgical diagnosis			
Pancreatic cancer (%)	73	80	50
Chronic pancreatitis (%)	20	0	10
Bile duct cancer (%)	7	0	10
Others (%)	0	20	30

Data are given as median (range in parenthesis) or as percentage.

ASA = American Society of Anesthesiologists; EDA = epidural anesthesia; NE = norepinephrine.

Statistical Analysis

All data are presented as median and range. As a normal distribution of the variables could not be assumed, only nonparametric tests were applied.

Intragroup changes in hemodynamic and sonographic variables were analyzed using the Wilcoxon's signed rank test (p_1 value). Because of the small number of patients in the EDA-NE group, the Wilcoxon's signed rank test was performed according to an exact approach. Intergroup differences with respect to proportional changes observed within the three groups were analyzed using one-way analysis of variance on ranks for independent random samples (Kruskal–Wallis) (p_2 value). In case of significance, changes observed in the EDA group and EDA-NE group were compared with changes in the control group according to Dunn's method. The statistical significance level was set to 0.05.

RESULTS

Thirty-two patients were included in this study. Two patients were excluded from further analysis; one patient because of the poor quality of sonographic images and the other patient of failure to insert the TEE probe into the stomach. No patient was excluded because of epidural catheter dislocation, because on the first postoperative day correct catheter position in the epidural space could be confirmed in all patients. Thus, the final evaluation was based on 30 patients, 20 patients with EDA and 10 patients without EDA (control group). The control group consisted of patients with failed insertion of the epidural catheter (n = 2), with epidural spread that could not be tested (n = 3) or where EDA did not reach the desired spread (n = 1), with contraindications for EDA (n = 2) and patients who refused EDA (n = 2).

After induction of EDA, five patients demonstrated a decrease in MAP below 60 mm Hg so that NE infusion was started (EDA-NE group). The remaining 15 patients with EDA (EDA group) did not receive any catecholamine during the study period.

Apart from gender distribution, there were no significant differences between groups (Table 1). The volume of mepivacaine required to induce sensory blockade from TH4 to TH11 was 10 mL (8–16 mL) in the EDA group and 9 mL (8–12 mL) in the EDA-NE group. There were no significant differences in end-tidal desflurane and CO_2 concentrations and amounts of administered fluids among the three groups (Table 2). The median NE dose given in the EDA-NE group was 0.06 (0.02–0.12) $\mu g \cdot kg^{-1} \cdot min^{-1}$.

Effects of EDA on Global Hemodynamic Variables

EDA was associated with a significant decrease in HR and MAP, whereas patients without EDA showed a slight increase in HR but no significant change in MAP (Table 3). In the EDA-NE group, administration of NE resulted in a median MAP of 78 mm Hg (range 75–104). HR and MAP changes observed in the EDA group were significant compared with those observed in the control group ($p_2 < 0.01$) (Table 3). EDA was not associated with a significant change in stroke volume index or cardiac index (Table 3) in the EDA or EDA-NE groups.

Effects of EDA on Hepatic Blood Flow

Neither EDA nor additional administration of NE altered the hepatic vein diameter (Table 4). EDA was associated with a significant decrease in hepatic stroke volume index in both hepatic veins (right hepatic vein: $P = 0.01$, middle hepatic vein: $P < 0.001$). As a result of a decreased HR and stroke volume index of hepatic blood flow, EDA was associated with significant reduction in blood flow index in the right hepatic vein (median decrease 24%, $P < 0.001$) and in the middle hepatic vein (median decrease 24%, $P < 0.001$) (Table 4) (Fig. 1).

All five patients of the EDA-NE group revealed a decrease in the hepatic stroke volume index, resulting in a marked decrease in hepatic blood flow index in the right hepatic vein (median decrease 39%, $P = 0.06$) and in the middle hepatic vein (median decrease 32%,

Table 2. Clinical Variables at Baseline and Repetition Measurement

	Baseline (before EDA)	Repetition (during EDA)	Absolute change
Desflurane et (vol %)			
EDA group	2.5 (2.1–3.5)	2.6 (2.0–3.1)	−0.1 ([−1.1]–0.4)
EDA-NE group	3.1 (1.8–4.2)	3.0 (2.0–4.0)	0.0 ([−0.3]–0.6)
Control group	2.7 (2.2–3.4)	2.8 (2.1–3.8)	0.1 ([−0.1]–0.7)
CO_2 et (mm Hg)			
EDA group	35 (32–44)	35 (31–42)	0 ([−5]–3)
EDA-NE group	33 (31–39)	38 (35–44)	5 (2–6)
Control group	36 (32–38)	37 (34–42)	1 ([−1]–7)
Crystalloids (mL)			
EDA group	500 (500–800)	700 (500–1100)	200 (0–500)
EDA-NE group	500 (500–700)	900 (600–1100)	400 (100–400)
Control group	500 (500–1400)	850 (500–1500)	100 (0–400)
Colloids (6% HES) (mL)			
EDA group	500 (500–1000)	500 (500–1100)	0 (0–600)
EDA-NE group	500 (500–500)	500 (500–500)	0 (0–0)
Control group	500 (500–1000)	500 (500–1000)	0 (0–0)

Data given as median (range). The control group did not receive epidural anesthesia.

EDA = epidural anesthesia; et = end-tidal; HES = hydroxyethyl starch; NE = norepinephrine.

Table 3. Effects of Epidural Anesthesia (EDA) on Global Hemodynamic Variables

	Before EDA	During EDA	% Change	p_1	p_2
HR (min^{-1})					
EDA group	52 (39–81)	48 (37–65)	−7 ([−19]–2)*	<0.01	<0.01
EDA-NE group	44 (40–67)	43 (35–52)	−4 ([−22]–7)	0.38	
Control group	51 (40–76)	58 (41–77)	+4 ([−4]–21)	0.04	
MAP (mm Hg)					
EDA group	71 (51–97)	61 (50–84)	−13 ([−38]–31)*	0.04	<0.01
EDA-NE group	66 (58–74)	78 (75–104)	+14 (5–79)	0.06	
Control group	79 (56–104)	80 (61–104)	+6 ([−8]–15)	0.06	
CVP (mm Hg)					
EDA group	12 (7–14)	11 (5–18)	0 ([−37]–29)	0.73	0.06
EDA-NE group	11 (10–14)	15 (11–16)	+27 (7–33)	0.06	
Control group	13 (8–18)	13 (10–18)	0 ([−7]–44)	0.38	
SVI (mL/m^2)					
EDA group	46 (36–67)	45 (32–68)	0 ([−11]–12)	0.43	0.37
EDA-NE group	61 (45–97)	64 (44–93)	−3 ([−4]–39)	1.00	
Control group	46 (33–58)	45 (41–61)	+3 ([−6]–30)	0.36	
CI ($L \cdot min^{-1} \cdot m^{-2}$)					
EDA group	2.5 (2.0–4.2)	2.4 (1.8–3.5)	−3 ([−22]–12)	0.28	0.02
EDA-NE group	3.0 (2.3–4.4)	2.8 (2.1–3.6)	−6 ([−31]–10)	0.69	
Control group	2.3 (1.8–3.6)	2.6 (1.8–4.0)	+10 ([−9]–33)	0.60	

Data given as median (range). Before EDA, patients in general anesthesia before implementation of EDA; during EDA, 30 min after implementation of EDA. The control group did not receive EDA. p_1 value, comparison of the dependent variables within one group "before EDA" versus "during EDA" (Wilcoxon's signed rank test); p_2 value, ANOVA of the proportional changes observed in the three groups (Kruskal–Wallis test).

% change = proportional change; HR = heart rate; MAP = mean arterial blood pressure; CVP = central venous pressure; SVI = stroke volume index; CI = cardiac index; NE = norepinephrine.

* $P < 0.05$ EDA group, respectively, EDA-NE group versus control group (Dunn test).

$P = 0.06$) (Table 4). In the control group, the hepatic stroke volume index and hepatic blood flow index remained constant in both veins.

A comparison of changes in blood flow index among the three groups was significant ($p_2 < 0.01$). Reduction in blood flow index in the EDA group and the EDA-NE group was significant compared with the control group.

DISCUSSION

In contrast to our hypothesis, we found a significant decrease in hepatic venous blood flow after induction of thoracic EDA. The combination of EDA with continuous infusion of NE seems to induce a further decrease in hepatic blood flow. However, cardiac output was not affected by EDA.

Hepatic blood flow in surgical patients can be altered by a variety of factors, including arterial blood pressure, posture changes, carbon dioxide levels, intravascular volume shifts, positive pressure ventilation, and volatile anesthetics.[1] In the present study, measurements were performed under general anesthesia and mechanical ventilation; hence, hepatic blood flow was presumably already decreased during baseline measurements. Many of the factors affecting hepatic blood flow, such as carbon dioxide levels, end-tidal desflurane concentration, and mode of ventilation remained constant during this investigation.

Table 4. Effects of Epidural Anesthesia on Hepatic Blood Flow

	Before EDA	During EDA	% Change	p_1	p_2
DM right HV (mm)					
EDA group	12.5 (8.8–16.0)	12.1 (8.5–15.7)	+1 ([−1]–8)	0.07	0.69
EDA-NE group	9.4 (7.6–13.5)	8.6 (7.6–13.4)	+1 ([−5]–9)	1.00	
Control group	11.6 (6.2–16.9)	11.8 (6.1–16.8)	+1 ([−2]–3)	0.38	
DM middle HV (mm)					
EDA group	10.3 (6.6–12.3)	10.2 (6.6–12.3)	+1 ([−4]–17)	0.92	0.78
EDA-NE group	8.2 (6.4–11.1)	8.3 (6.5–11.8)	−1 ([−6]–4)	1.00	
Control group	8.9 (6.4–9.7)	8.8 (6.3–9.9)	0 ([−4]–2)	0.97	
SVI right HV (mL/m^2)					
EDA group	3.4 (1.7–7.0)	3.4 (1.4–5.3)	−16 ([−44]–14)	0.01	0.02
EDA-NE group	2.5 (1.5–4.8)	1.8 (1.2–4.3)	−22 ([−50]–[−8])*	0.06	
Control group	2.8 (1.2–9.1)	2.9 (1.3–8.9)	+8 ([−22]–52)	1.0	
SVI middle HV (mL/m^2)					
EDA group	2.7 (1.4–5.8)	2.3 (1.2–4.2)	−15 ([−38]–5)	<0.01	<0.03
EDA-NE group	2.2 (1.0–4.8)	1.4 (0.9–4.2)	−13 ([−36]–[−6])	0.06	
Control group	1.9 (0.6–3.6)	1.8 (0.8–4.1)	0 ([−23]–43)	0.74	
Blood flow index right HV ($mL \cdot min^{-1} \cdot m^{-2}$)					
EDA group	165 (83–428)	132 (63–282)	−24 ([−43]–5)*	<0.01	<0.01
EDA-NE group	114 (103–205)	68 (62–176)	−39 ([−45]–[−11])*	0.06	
Control group	159 (57–515)	159 (80–518)	+13 ([−23]–56)	0.49	
Blood flow index middle HV ($mL \cdot min^{-1} \cdot m^{-2}$)					
EDA group	168 (54–377)	124 (50–246)	−24 ([−45]–[−3])*	<0.001	<0.01
EDA-NE group	93 (67–204)	63 (47–190)	−32 ([−49]–[−7])*	0.06	
Control group	111 (27–158)	103 (39–200)	+3 ([−33]–46)	0.49	

Data given as median (range). Before EDA: patients in general anesthesia before implementation of EDA; during EDA: 30 min after implementation of EDA. The control group did not receive EDA. p_1 value, comparison of the dependent variables within one group "before EDA" versus "during EDA" (Wilcoxon's signed rank test); p_2 value, ANOVA of the proportional changes observed in the three groups (Kruskal–Wallis test).

% change = proportional change; DM = diameter; HV = hepatic vein; SVI = stroke volume index; NE = norepinephrine; EDA = epidural anesthesia.

* $P < 0.05$ EDA group, respectively, EDA-NE group versus control group (Dunn test).

As all measurements were performed before surgery and fluid administration was continued during the study period, we presume that there was no decrease in intravascular volume.

Hepatic blood flow was assessed by use of TEE, which is limited to the assessment of blood flow in the right and middle hepatic vein.[11] Hence, this method does not allow the assessment of total hepatic blood flow. However, as we observed similar blood flow changes in the right and middle hepatic vein, it may be assumed that the observed changes mirror those in total hepatic blood flow. Because of a marked interindividual variety in the anatomy of hepatic veins, we observed large interindividual differences in hepatic vein diameters and in blood flow of the hepatic veins. Presumably, this is the reason for the differences in median hepatic vein blood flow values among the three groups. On the basis of these considerations, we restricted intergroup comparisons to proportional changes in hepatic blood flow. With respect to the reproducibility of TEE-based hepatic blood flow measurements, in a former study, we found an inter- and intraobserver variability for the right and middle hepatic veins between 6.8% and 9.2%.[12]

Presumably, the main reason for the observed decrease in hepatic blood flow is the EDA-related decrease in systemic arterial blood pressure. The negative effects of the decrease in systemic arterial blood pressure prevail over the anticipated positive effects of local vasodilation. One reason for the arterial blood pressure effect of hepatic blood flow regulation might be that the hepatic artery exhibits almost no autoregulatory capacity, as a nearly linear correlation between systemic arterial blood pressure and hepatic arterial blood flow has been found.[18,19] The present study does not provide data about the sole effects of EDA on hepatic blood flow independent of changes in arterial blood pressure.

The effects of thoracic EDA on hepatic blood flow have been investigated in only one animal study. In contrast to the present study, Vagts et al.,[7] using a pig model, observed an unaltered total hepatic blood flow after induction of thoracic EDA (TH5–TH12) despite a decrease in MAP 30%. The reasons for the discrepancy between the data found in pigs and our findings in humans may be species related and could be due to different physiological reactions on EDA-induced sympathicolysis.

Two human studies have been performed to evaluate the effects of high lumbar EDA on hepatic blood flow. Kennedy et al.[5] measured hepatic venous flow in conscious volunteers by the indocyanine green clearance technique using a hepatic venous catheter and, after induction of high lumbar EDA, found a decrease in hepatic blood flow of 25% despite a constant cardiac output. Tanaka et al. also performed a high lumbar EDA.[6] They estimated hepatic blood flow by pulse densitometric determination of the indocyanine green

plasma disappearance rate and reported a decrease in hepatic blood flow of 35%. In contrast to these two preceding studies in humans we performed thoracic EDA and assessed hepatic blood flow changes by use of Doppler sonography. Nevertheless, we found almost the same reduction in hepatic blood flow as reported by Kennedy et al.[5] and Tanaka et al.[6] Thus, the present data do not support the hypothesis that thoracic EDA is superior to lumbar EDA with respect to the effects on hepatic perfusion.

All five patients treated with NE to compensate for the EDA-induced decrease in arterial blood pressure had a marked decrease in hepatic blood flow. Neither human nor experimental studies have been performed to investigate the effects of NE in combination with EDA on hepatic blood flow. Experimental studies assessed the sole effect of NE on hepatic blood flow and consistently found a decrease in flow between 20% and 45%.[20,21] The present data do not suggest that EDA attenuates NE-induced vasoconstriction in the splanchnic bed.

We cannot draw any conclusions as to what extent the observed decrease in hepatic blood was associated with alterations in hepatic oxygen balance and metabolic activity. However, the decrease might be relevant in specific patient groups, such as those with preexisting liver disease or those undergoing hepatic surgery. Outcome studies should be performed to evaluate EDA with respect to possible perioperative hepatic damage and other variables, especially in these patient groups. Also, the intraoperative use of NE in combination with EDA, should be investigated in outcome studies and compared with other vasopressor therapies.

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