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Epidural anaesthesia with levobupivacaine and ropivacaine : effects of age on the pharmacokinetics, neural blockade and haemodynamics

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**CARDIOVASCULAR PARAMETERS AND LIVER BLOOD FLOW
AFTER INFUSION OF A COLLOID SOLUTION AND EPIDURAL
ADMINISTRATION OF ROPIACAINE 0.75%.
THE INFLUENCE OF AGE AND LEVEL OF ANALGESIA**

CHAPTER 12

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Both spinal and epidural anaesthesia may, depending upon the extent of sympathetic blockade, be accompanied by profound cardiovascular effects.^{1,2} For any given dose, the upper level of analgesia, and thus of sympathetic blockade, is generally higher in elderly compared to young adult patients.^{3,4} Consequently, cardiovascular effects of epidural anaesthesia are often more profound in elderly patients than in young adult patients.⁴ So far, most studies on the cardiovascular effects of epidural anaesthesia focussed on changes in blood pressure and pulse rate.⁵ In contrast to the effect of spinal anaesthesia⁶ and the impact of age on the haemodynamics after spinal anaesthesia,^{7,8} the effect of epidural anaesthesia⁹ and the possible influence of age on cardiac output have not been investigated extensively.

During epidural anaesthesia the liver blood flow decreases.^{9,10} In addition, liver blood flow seems to be reduced in the elderly patients.¹¹ These factors may influence the elimination of drugs with a high extraction ratio, potentially influencing their clinical effect. Furthermore, little is known about the liver blood flow during central neuraxis blockade in older, compared to younger patients.¹²

Volume administration before spinal anaesthesia appears to be important to minimize the risk of hypotension in the elderly. It is not known if the effect of volume administration before epidural anaesthesia may be effective in the elderly.¹³

Pulse dye densitometry has been developed to measure the blood concentration-time curves of indocyanine green (ICG) non-invasively in individual patients. From these curves the cardiac output,^{14,15} blood volume^{16,17} and liver blood flow^{6,9,10,12} have been determined with accuracy.

We used pulse dye densitometry of ICG to investigate the influence of age on the cardiac output, blood volumes and hepatic blood flow after rapid infusion of a colloid solution and after consecutive epidural anaesthesia with ropivacaine. In addition, we measured the changes in haemodynamic variables during rapid infusion of the colloidal solution and during induction of epidural anaesthesia. Finally, the effects of age and the highest level of analgesia on the haemodynamic variables were studied.

Materials and Methods

Subjects

The protocol of this study was reviewed and approved by the Committee on Medical Ethics of the Leiden University Medical Center. The study was conducted in accordance with the provisions stated in the Declaration of Helsinki and later revisions thereof.

We aimed at inclusion of 30 patients, ASA I or II, equally distributed over three age groups (Group 1: 20-44 yr; Group 2: 45-70 yr; Group 3: > 70 yr), who had eligible data for all three experiments. Patients were scheduled to have orthopaedic, urological, gynaecological (excluding obstetrics) or abdominal surgery under epidural anaesthesia with or without supplemental general anaesthesia.

Patients with a history of cardiac or vascular disease, including hypertension, were excluded from the study. Hypertension was defined as a mean diastolic blood pressure of > 100 mm Hg and/or mean systolic blood pressure > 160 mm Hg at three measurements. Patients taking antihypertensive drugs, including diuretics, as well as antiarrhythmics or α_1 -sympatholytic medication for benign prostate hypertrophy, were excluded. Furthermore, patients who had a history of known hypersensitivity to amide local anaesthetics, severe respiratory, renal, hepatic disease, diabetes mellitus, or neurological, psychiatric or seizure disorders were excluded. In addition, pregnant women, as well as patients with a positive Allen's test (no collateral flow) at both upper extremities were excluded.

Preparations

Patients fasted from midnight the day before the study. They received temazepam 20 mg (< 60 yr) or 10 mg (\geq 60 yr) orally approximately 45-60 min before the procedure. During the study period the patient remained in the holding area or an operation theatre. The patient was attached to a non-invasive automated blood pressure measurement device and monitor (Cardiacap, Datex-Ohmeda, Helsinki, Finland) and to the electrocardiogram (ECG) for continuous registration of the heart rate and rhythm. An intravenous cannula was inserted into a large vein in the forearm or the antecubital fossa for fluid and drug administration. An amount of 20 ml.h⁻¹ saline 0.9% was infused continuously to assure the patency of the intravenous cannula. After local infiltration of the skin with lidocaine 1%, an arterial cannula was inserted in the radial artery, preferentially in the non-dominant arm. This arterial cannula was used for blood pressure measurements. The arterial catheter was removed after completion of surgery.

Subsequently, after local infiltration of the skin with lidocaine 1.0%, lumbar puncture was performed with a 16-gauge Hustead needle at the L2-L3 or L3-L4 lumbar interspace with the patient in the sitting position. Using a median or paramedian approach, the epidural space was identified using the loss of resistance to saline technique (volume of saline ≤ 10 ml). An epidural catheter was inserted 5 cm into the epidural space. After excluding an intravascular or subarachnoid positioning of the catheter by aspiration, a bacterial filter was attached and the catheter was capped sterilely. Thereafter, the patient was placed in the supine horizontal position. The optical sensor of the pulse dye densitometer (DDG-2001; Nihon-Kohden, Tokyo, Japan), used for non-invasive measurement of the plasma concentration-time profile of indocyanine green (ICG), was connected to the index finger of the dominant arm.

Procedures

Before every determination of ICG plasma concentrations, a 1-ml arterial blood sample was taken to measure the Hb-concentration, for calibration of the pulse dye densitometer. In total, three experiments were performed (Figure 1). The first experiment took place after a 10-min stabilising period after the lumbar puncture. In this experiment the plasma concentration-time curve of ICG was determined by pulse dye densitometry for a period of 10 min, after intravenous administration of a 10 mg ICG bolus. During the same period heart rate and invasive arterial blood pressure were continuously measured.

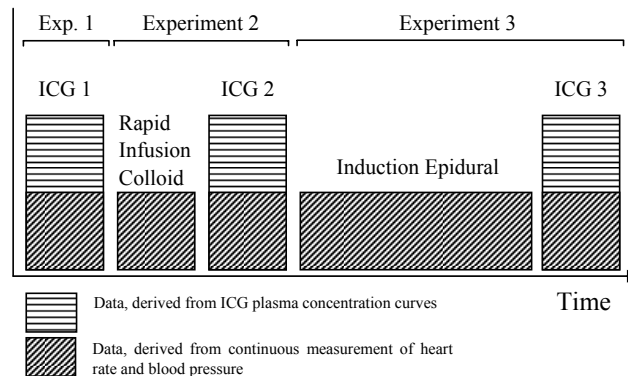


Figure 1. Schematic representation of the time course of the three experiments performed in this study.

The second experiment was performed directly hereafter. An amount of 500 ml of a colloid solution (hydroxyethyl starch 6% (HES 6%); Voluven®) was administered within 10 minutes by rapid intravenous infusion. When the infusion was ended, the plasma concentration-time curve after another bolus of 10 mg of ICG was determined, as described above. Heart rate and invasive arterial blood pressure were continuously measured from the start of the infusion until 10 min thereafter and during the ICG-concentration measurements.

Subsequently, the third experiment took place. A test dose of 3 ml prilocaine 1% with epinephrine $5 \mu\text{g}\cdot\text{ml}^{-1}$ was epidurally administered at a rate of $1 \text{ ml}\cdot\text{s}^{-1}$. After three minutes, when there were no signs of intravascular or subarachnoid location of the epidural catheter, 15 ml ropivacaine 0.75% was administered at a rate of $1 \text{ ml}\cdot\text{s}^{-1}$. During a 30-min period after completion of the epidural administration heart rate and invasive arterial blood pressure were measured. When a stable sensory blockade had been established (see Assessments) the ICG concentrations were measured, as described above. This did not take place earlier than 20 min after the start of the epidural administration or earlier than 15 min after a bolus administration of ephedrine, administered to treat hypotension. Consequently, during the ICG concentration measurements heart rate and invasive arterial blood pressure were recorded.

Assessments

The arterial blood pressure was monitored throughout the study period using a pressure transducer (Edward Lifesciences LLC, Irvine, Ca, USA). Systolic blood pressure (SBP), mean arterial pressure (MAP), diastolic blood pressure (DBP) and heart rate (HR) during the abovementioned periods were recorded at 1-minute intervals in a data file.

Hypotension (decrease in SBP $> 30\%$ of the pre-experimental value or SBP $< 90 \text{ mm Hg}$) was treated by administering ephedrine 5 mg intravenously. Bradycardia ($< 55 \text{ beats}\cdot\text{min}^{-1}$) was treated by administering atropine 0.5 mg intravenously.

After epidural injection of ropivacaine the highest level of analgesia was determined bilaterally in the anterior axillary line using a short-bevelled 25-gauge needle. Analgesia was defined as the inability to detect a sharp pinprick. Assessments were made at 5-min intervals during the first 30 min after epidural administration or until a stable level of analgesia had developed. A stable level of analgesia was defined as an unchanged upper level during 2 consecutive assessments.

Data analysis

After every experiment, the plasma concentration-time data of ICG, determined by the pulse dye densitometer was sent to a laptop-computer attached to it. Subsequently, from these data parameters were calculated using a spreadsheet program (Excel 2000, Microsoft Corporation). Cardiac output (CO) was calculated by dividing the administered dose of ICG by the area under the first-pass concentration-time curves, which were constructed from the plasma concentration-time data of the pulse dye densitometer. Total blood volume was estimated as $TBV=D/C_0$, in which D is the dose administered and C_0 is the back-extrapolated concentration at mean transit time (MTT), when first mixing but no elimination of ICG has occurred during the first circulation. The MTT can be determined using the modified Stewart-Hamilton technique as follows:

$$MTT = \frac{AUMC_{first}}{AUC_{first}}$$

where $AUMC_{first}$ is the area under the curve of the product of concentration and time versus time during the first circulation.

The central blood volume (CBV) is determined as the product of CO and MTT. The elimination clearance of ICG can be considered as a measure of liver blood flow and was calculated as the dose of ICG divided by the area under the entire blood concentration-time curve from time zero to infinity. Subsequently, liver blood flow was estimated as:

$$Q_h = \frac{CL_{ICG}}{E_h}$$

where Q_h is liver blood flow, CL_{ICG} the clearance of ICG and E_h the estimated liver extraction ratio. The value of E_h for ICG was assumed to equal 0.7.

Statistical analysis

Measured cardiovascular parameters (HR, SBP, MAP, DBP) were analysed, using analysis of variance (repeated measures design), allowing evaluation of the effects of the intervention and age groups. *Post-hoc* tests with a Bonferroni correction for multiple comparisons were performed for age groups. The highest levels of analgesia between the 3 age groups were compared using the Kruskal-Wallis test, followed by Mann-Whitney U tests. A correction for multiple comparisons was made using the sequentially rejective Bonferroni-Holm method.

The cardiovascular parameters (CO, CI), blood volumes (CBV, TBV) and liver blood flow (Qh), derived from the plasma concentration time data of ICG were analysed using analysis of variance (repeated measures design) between experiment 1 and 2 and between 2 and 3.

The number of patients experiencing one or more episodes of hypotension or bradycardia after induction of epidural anaesthesia was compared between age groups using the Chi-square test or Fisher's exact test. In addition, correlations between age and/or the highest level of analgesia and the mean difference in cardiovascular parameters during the first 30 min after start of epidural anaesthesia are analysed by Kendall's tau (τ).

Results

Subjects

Thirty-six patients were included in the study to obtain 30 eligible patients (10 patients per age group), who had complete data sets. However, data from all patients were used in the analysis. In 5 patients no data of the epidural experiment were collected, because of technical failure of the epidural block (no block in 2 patients, patchy block or unilateral block each in 1 patient, radicular pain at start of epidural administration in 1 patient). In one patient at the middle-aged patients group, only the CO was obtained for the first two ICG experiments. Patients' characteristics are shown in Table 1. Height and weight did not differ significantly among age groups.

Table 1. Patient characteristics of all patients included. Data are mean (range) for age, mean \pm SD or frequencies.

	Group 1 (20-44 years) (n = 10)	Group 2 (45-70 years) (n = 15)	Group 3 (> 70 years) (n = 11)
Age (years)	33 (21-44)	56 (46-69)	77 (71-86)
Gender (M/F)	2/8	6/9	4/7
ASA (I/II)	7/3	6/9	3/8
Height (cm)	173 \pm 6	174 \pm 8	166 \pm 10
Weight (kg)	73 \pm 10	76 \pm 13	69 \pm 12

Does age affect the haemodynamic response to, and liver blood flow after, colloid infusion?

The mean values of HR, SBP, MAP and DBP for the 3 age groups during a 10-min period after the start of the rapid infusion of the colloid solution are shown in Figure 2. Mean values of the variables CO, CI, CBV, TBV and Qh for the 3 age groups and before and after the infusion are shown in Figure 3. Results of the analysis are shown in Table 2. Heart rate, SBP and MAP increased significantly during rapid infusion. However, the mean differences were small when the mean values at the start of the infusion were compared to those of 10 minutes thereafter (mean difference are 2.1 BPM, 4.1 mm Hg and 2.7 mm Hg for HR, SBP and MAP, respectively). In addition, CBV was significantly greater (mean difference \pm SD: 0.44 ± 0.20 l) and Qh was higher (196 ± 92 ml) after administration of the colloid solution. No difference between age groups were present for all abovementioned variables.

Table 2. Significance levels (*P*-values) for haemodynamic variables, blood volumes and liver blood flow during rapid infusion of voluven. **P* < 0.05 is considered significant.

	ANOVA with repeated measurements		
	Infusion of colloid solution	Age group	Interaction
Heart rate	1E-05*	0.10	0.80
Systolic blood pressure	0.03*	0.21	0.20
Mean arterial pressure	0.04*	0.39	0.09
Diastolic blood pressure	0.07	0.51	0.45
Cardiac output	0.11	0.31	0.66
Cardiac index	0.14	0.57	0.69
Central blood volume	0.04*	0.08	0.15
Total blood volume	0.21	0.53	0.88
Liver blood flow	0.04*	0.51	0.42

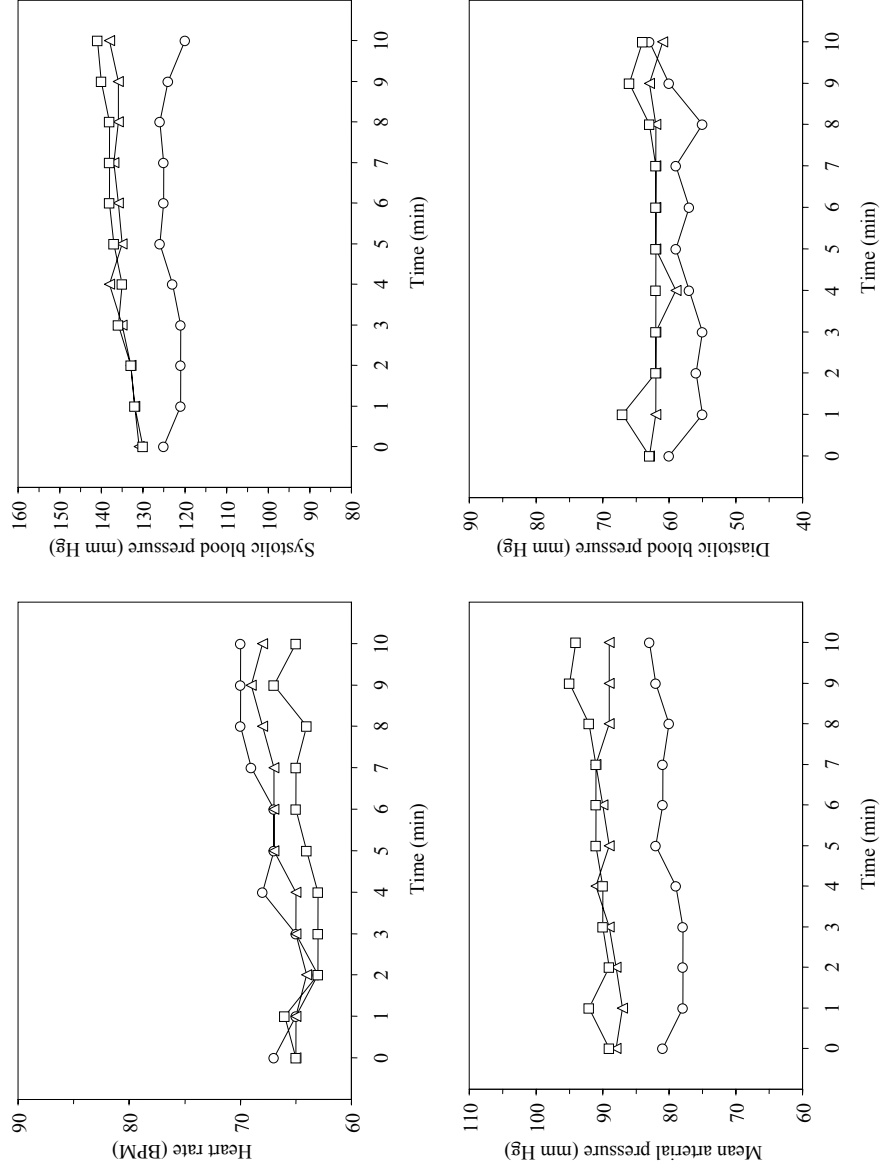


Figure 2. Mean values of heart rate, systolic blood pressure, mean arterial pressure and diastolic blood pressure during rapid infusion (<10 min) of 500 ml of a colloid solution (Voluven®). The infusion was started at time t = 0 min. The lines represent the youngest (O), middle-aged (Δ) and oldest group of patients (□), respectively.

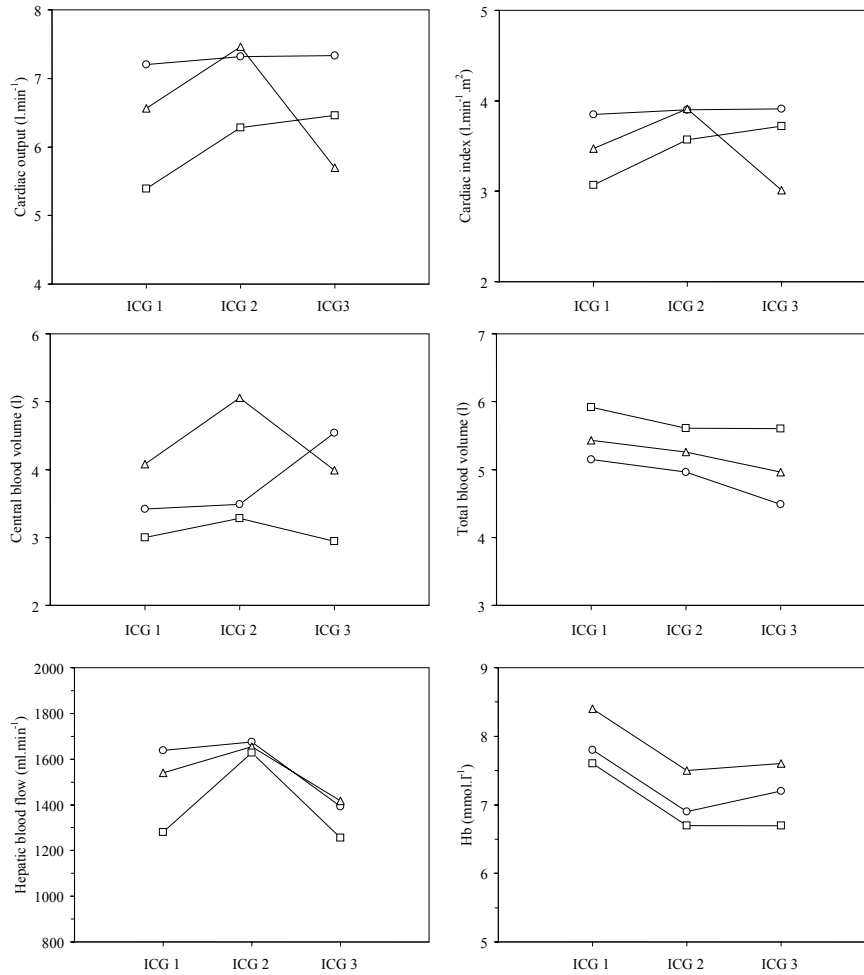


Figure 3. Mean values of cardiac output, cardiac index, central blood volume, total blood volume and liver blood flow, derived from the plasma concentration-time curves of ICG, which were determined by pulse dye densitometry. In addition, mean values of hemoglobin concentrations are shown. Results are presented for the three age groups (young (○), middle-aged (△), and elderly (□) patients, respectively) and those derived after the three ICG-experiments.

Does age affect the haemodynamic response to, and liver blood flow after, epidural administration of ropivacaine?

The upper level of analgesia was significantly higher in the eldest (median (range): T4 (T10-C7/T1)), compared to the youngest age group (T6/T7 (L2-Th4); $P = 0.036$) (Figure 4). Changes in HR, SBP, MAP and DBP after epidural administration of ropivacaine are presented in figure 5. Heart rate increased significantly the first 15-20 minutes, then returned to normal. Although the heart rate in the elderly seemed to be rather constant graphically, in contrast to the other age groups, there was no statistical difference (Table 3). Additionally, SBP, MAP and DBP decreased significantly during epidural anaesthesia. The oldest age group showed a larger decrease in SBP ($P = 0.04$) and DBP ($P = 0.03$), compared to the middle and younger age group, respectively. However, interaction between the intervention, *i.e.*, epidural administration of ropivacaine (test of within subjects effects) and age group (test of between subjects effects) was present. This means that the older patients had both higher blocks and more significant blood pressure changes.

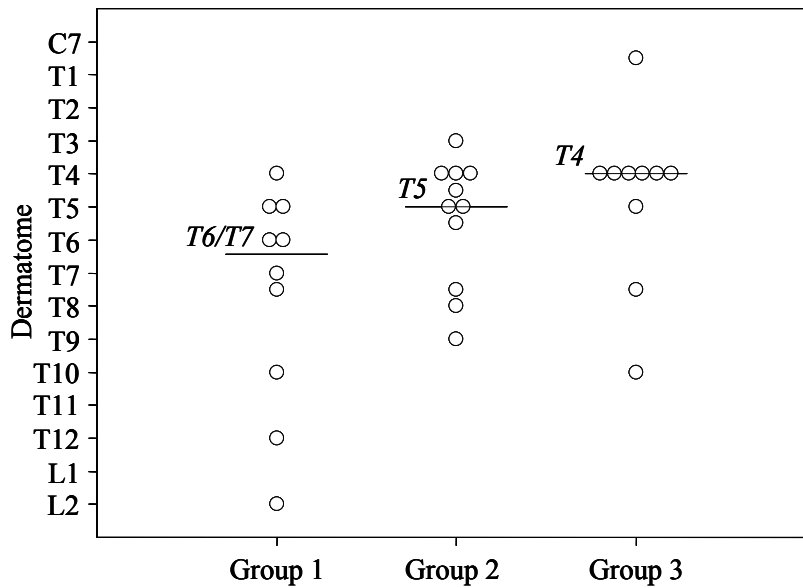


Figure 4. The upper level of anaesthesia after epidural anaesthesia with ropivacaine 0.75%. Individual data (O) and median values (horizontal line) are shown for the three age groups (Group 1: 20-44 years, Group 2: 45-70 years and Group 3: > 70 years).

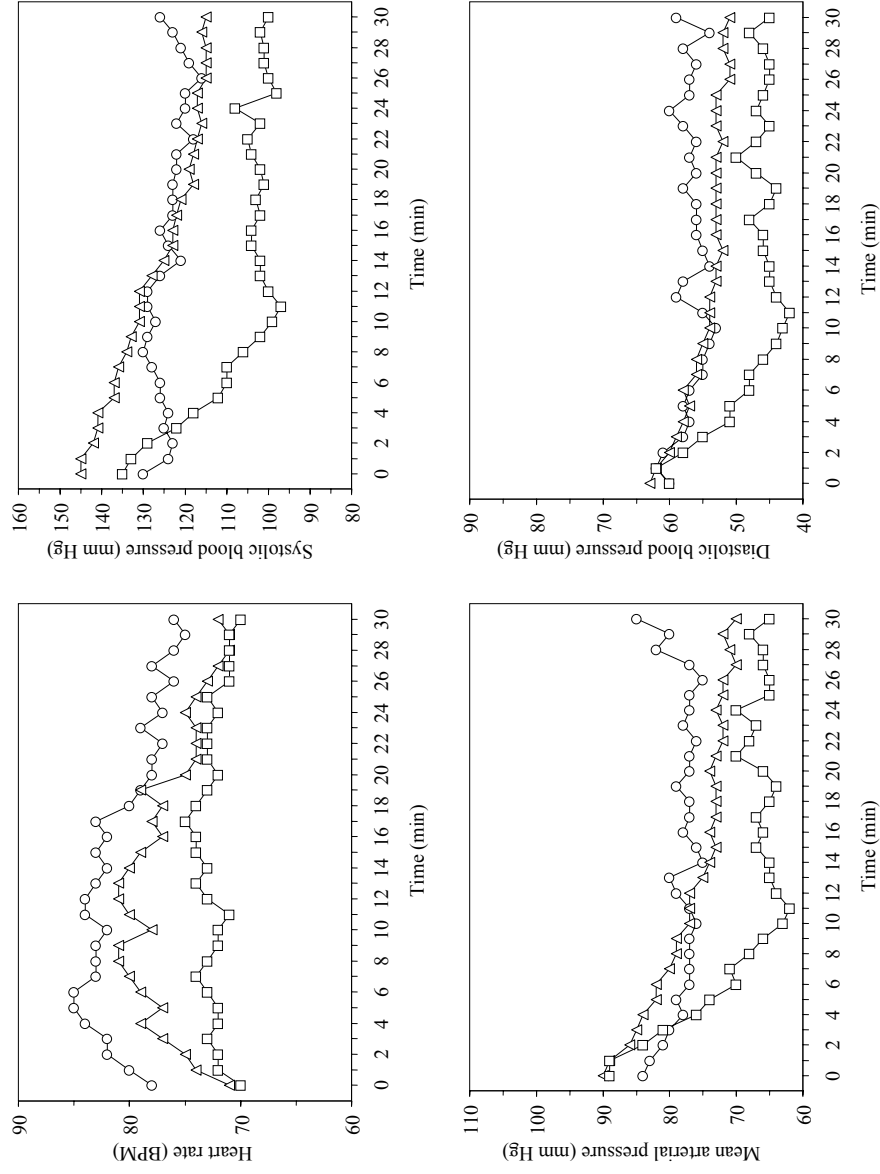


Figure 5. Mean values of heart rate, systolic blood pressure, mean arterial pressure and diastolic blood pressure during the first 30 min after epidural administration of ropivacaine 0.75%. The epidural injection was started at time = 0 min. The lines represent the youngest (O), middle-aged (Δ) and oldest group of patients (□), respectively.

The correlations between age or the highest level of analgesia and the mean difference of HR, SBP, MAP and DBP during the first 30 min after induction of epidural anaesthesia were determined (Table 4). Analysis showed that the correlations between age and each of the abovementioned haemodynamic parameters were in the same range of the correlation between the highest level of analgesia and each of these parameters. Age and highest level of analgesia showed a moderate relationship ($\tau=0.42$).

After induction of epidural anaesthesia Qh decreased significantly ($P = 0.005$), whereas CO, CI, CBV, TBV did not change (Table 3). No differences were observed for these parameters between age groups before and after epidural induction. During the first 30 min of epidural anaesthesia 10%, 45% and 60% of the young, middle-aged and oldest patients, respectively, experienced at least one episode of hypotension. Only one patient, in the middle aged group, had a heart rate < 55 BPM.

Haemodynamic variables, such as HR, SBP, MAP and DBP remained stable during the collection of ICG plasma concentration-time data at all 3 experiments.

Table 3. Significance levels (P -values) for haemodynamic variables, blood volumes and liver blood flow after epidural administration of ropivacaine 0.75%. * $P < 0.05$ is considered significant.

	ANOVA with repeated measurements		
	Epidural administration	Age group	Interaction
Heart rate	0.0002*	0.25	0.23
Systolic blood pressure	1E-07*	0.03*	0.01*
Mean arterial pressure	1E-09*	0.12	0.01*
Diastolic blood pressure	1E-08*	0.03*	0.04*
Cardiac output (CO)	0.36	0.58	0.27
Cardiac index (CI)	0.40	0.66	0.27
Central blood volume (CBV)	0.65	0.16	0.06
Total blood volume (TBV)	0.06	0.36	0.39
Liver blood flow (Qh)	0.005*	0.79	0.88

Table 4. Correlations between age and/or highest level of analgesia and the mean difference of haemodynamic parameters during the first 30 minutes after epidural administration of ropivacaine. Δ_m = Mean difference during the first 30 min after epidural administration of ropivacaine 0.75% of the heart rate, the systolic blood pressure, mean arterial pressure and diastolic blood pressure. τ = Kendall's tau. * $P < 0.05$ is considered significant.

		τ	Significance
Age	Highest level of analgesia	0.42	2E-03*
Age	Δ_m Heart rate	0.06	0.646
	Δ_m Systolic blood pressure	-0.38	3E-03*
	Δ_m Mean arterial pressure	-0.44	6E-04*
	Δ_m Diastolic blood pressure	-0.41	1E-03*
Highest level of anaesthesia	Δ_m Heart rate	-0.03	0.821
	Δ_m Systolic blood pressure	-0.52	9E-05*
	Δ_m Mean arterial pressure	-0.56	2E-05*
	Δ_m Diastolic blood pressure	-0.48	3E-04*

Discussion

The aim of the study was to investigate the changes in haemodynamic variables and liver blood flow during infusion of a colloid solution and during induction of epidural anaesthesia with ropivacaine. We demonstrated that during colloid infusion HR, SBP, MAP and Qh increase, but that this was not affected by advancing age. In addition, the heart rate increased during the first 15 minutes after epidural administration of ropivacaine and the SBP, MAP and DBP decreased. Older patients had a higher risk of hypotension and showed a larger decrease in SBP and DBP compared to their younger counterparts. Both the highest level of analgesia and age correlated to the same degree with the mean decrease in SBP, MAP and DBP during the first 30 min after epidural administration of ropivacaine.

The haemodynamic effects of preloading have been described by Ueyama *et al.*¹⁸ They also observed a modest, however not significant increase in HR and SBP after administration of 0.5 l of a colloid solution (HES 6%). In contrast to our study, they found that the CO increased after preloading with 0.5 l of HES 6%. However, their study was

performed in healthy full-term parturients. Our study population differed in that no pregnant women were included and that we investigated a wide range of ages.

The liver has a dual efferent vascular system, consisting of the hepatic artery, accounting for approximately 30% and the vena porta delivering the remaining 70% of the total blood flow to the liver.¹⁹ Liver blood flow depends primarily on the mean systemic arterial pressure, rather than the cardiac output.^{6,9,10} We found that preloading with a colloid solution led to an increased MAP, possibly increasing the perfusion of the splanchnic circulation and, thus, to a higher portal vein blood flow. This may explain that Qh increased during preloading in our study.

There are hardly any data about the haemodynamic effects of colloid fluids during epidural blockade in the elderly. In this epidural study, the cardiac output was not influenced by age. After subarachnoid blockade haemodynamic effects, assessed by transthoracic electrical bioimpedance in elderly patients, revealed that systolic blood pressure decreased by 25%.⁷ The cardiac output was unaffected, because the stroke index in some patients was compensated by an increase in heart rate. In another study, administration of 8 ml.kg⁻¹ colloid solution in elderly patients undergoing spinal anaesthesia, cardiac index increased by 12%.⁸ The time course of the haemodynamic effects are different between epidural and subarachnoid administration because the onset of sympathetic blockade occurs more rapidly after spinal anaesthesia. Furthermore, study population differed between the studies, because we excluded patients with any cardiovascular disease or taking concomitant antihypertensive, cardiac or vasoactive medication.

High levels of analgesia, and thus of sympathetic blockade, are associated with a larger decrease in arterial blood pressure after epidural anaesthesia.^{2,4} In this study, increased age was associated with higher levels of analgesia, confirming earlier observations with epidurally administered bupivacaine³ and ropivacaine.⁴ Consequently, the higher incidence of hypotension and the larger decrease in blood pressure in the elderly may be attributed to the higher level of analgesia attained in this population. However, age itself may be a factor, contributing to hypotension after epidural anaesthesia. This may be related to the anatomic and physiologic changes in the cardiovascular and autonomic nervous system that occur with increasing age. Changes in the cardiovascular system comprise the stiffening of vessels, subsequent hypertrophy of the left ventricle of the heart as the result of early reflected pulse pressure waves²⁰ and decrease in cardiac reserve.²¹ Changes in the autonomic nervous system that occur with increasing age are a decrease in the response to beta-adrenoreceptor stimulation²² and decline of the baroreflex sensitivity.²³ These abovementioned factors may all contribute to substantial hypotension in elderly patients after epidural anaesthesia. In addition, cardiovascular compensation mechanisms may be less than optimal in the elderly. This may be explained for a great

part by a reduced baroreceptor-mediated response of the heart rate on exercise and stress in these patients.²¹ The baroreflex regulation of sympathetic vasoconstrictor outflow is not impaired with increasing age.²³

For spinal anaesthesia, Carpenter *et al.*²⁴ determined risk factors related to the occurrence of hypotension and bradycardia. Peak block height \geq T5 and age \geq 40 years were associated with an higher incidence of hypotension, whereas only the first factor was associated with a higher incidence of bradycardia. From our study it is not possible to conclude which factor, *i.e.*, the highest level of analgesia or age per se, is most important in the development of hypotension after epidural anaesthesia. Both factors were correlated with a decrease in the systolic and diastolic blood pressure, and subsequently with a decrease in mean arterial pressure. However, age and the highest level of analgesia were also positively correlated. The low incidence of bradycardia observed in this study may be related to the relatively few people who attained a sensory blockade \geq T5.

Epidural anaesthesia decreased Qh in this study, which confirms earlier observations.^{9,10} Administration of a colloid solution before epidural dosing did not prevent a decline in Qh. Tanaka *et al.*¹⁰ showed that continuous infusion of a colloid solution (HES), maintaining normotension, did not prevent a decrease in Qh after epidural anaesthesia, but that infusion of dopamine could reverse a decline in Qh. Wynne *et al.*¹¹ showed a negative correlation between advancing age and liver blood flow. However, no difference between age groups was observed in this study, with regard to Qh, as well as to the decrease in Qh after induction of epidural anaesthesia.

Indocyanine green (ICG) is exclusively eliminated from the blood by the liver with a half life of 150-180 s.²⁵ It binds avidly to plasma proteins, so that its distribution equals blood plasma volume. From the plasma concentration curves of ICG, cardiac output, blood volumes and liver blood flow can be determined. Pulse dye densitometry has been developed to measure ICG plasma concentrations non-invasively. This method determines photometrically the ratio of ICG concentration to haemoglobin concentration at two wavelengths (805 and 890 nm, respectively) at each pulse.¹⁴ Because the haemoglobin is the reference to which the concentration of ICG is compared, the haemoglobin concentration has to be measured by another device. ICG-concentrations are measured using an optical sensor device, positioned at the fingertip or nostril.

Non-invasive pulse dye densitometry has been shown to estimate with good accuracy the cardiac output, compared to invasive methods like thermodilution.^{14,15} In addition, the total blood volume (TBV) and central blood volume (CBV) were accurately estimated using this method.^{16,17} Also, liver function and liver blood flow after partial hepatectomy or liver transplantation flow have been adequately assessed by pulse dye densitometry.^{26,27}

Therefore, pulse dye densitometry was used to derive the ICG-concentration curves, from which CO, CBV, TBV and k were estimated.

In conclusion, we determined changes in haemodynamics, blood volumes and liver blood flow after infusion of 500 ml of a colloid solution and after consecutive epidural administration of ropivacaine. After colloidal infusion, a modest increase in HR, SBP and MAP, as well as an increase in CBV and Qh occurred. After epidural administration of ropivacaine HR increased during the first 15 minutes and the SBP, MAP and DBP, as well as Qh decreased. Old age was associated with a higher incidence of hypotension and a larger decrease in SBP and DBP. These observations may be explained by the higher level of analgesia, attained in older patients, but probably also by the changes in the cardiovascular and autonomic nervous system that occur with ageing. In addition, no age-related differences were found for the CO, CBV, TBV and Qh after colloid infusion and after induction of epidural anaesthesia. Although rapid colloid infusion only had a mild effect on the haemodynamics in the elderly, it did not prevent a decrease in Qh after epidural anaesthesia.

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