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Systemic Hypotension Following Intravenous Administration of Nonionic Contrast Medium During Computed Tomography: Iopromide Versus Iodixanol

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BACKGROUND: In light of the increasing number of radiologic interventions performed under general anesthesia, the effects of contrast media (CM) on circulation and organ perfusion are of paramount importance. The objectives of this study were to systematically quantify effects on blood pressure, heart rate, and kidney function following intravenous administration of nonionic CM with normal and low osmolality.

METHODS: In this controlled, double-blinded phase IV clinical trial, 40 consecutive patients were randomly assigned to receive repeated measures of either low-osmolar iopromide or iso-osmolar iodixanol. Normal saline solution (NSS) served as control. Blood pressure and heart rate were measured continuously from 1 minute before until 3 minutes after administration of CM and NSS. Urine output was recorded hourly.

RESULTS: Administration of iopromide resulted in systemic hypotension lasting up to 300 seconds (105 ± 61 seconds) with the lowest mean arterial pressure of 39 mm Hg (56.7 ± 12.2 mm Hg). Iopromide caused a systolic/diastolic decrease of 31/26 mm Hg ($P < .001$), significant increase in heart rate ($P = .042$), and significant diuresis with a 2-fold higher per-hour urine output ($P = .010$). Administration of iodixanol and NSS had no significant influence on blood pressure ($P > .640$).

CONCLUSIONS: Administration of low-osmolar iopromide was followed by a significant transient decrease in blood pressure and a rise in heart rate. Anesthetists and radiologists should be aware of these effects in patients in whom short episodes of disturbed tissue microcirculation may pose a clinical risk. (Anesth Analg 2018;126:769–75)

Intravenous administration of iodinated nonionic contrast medium (CM) shows rheological, coagulatory, physiological, electrophysiological, and hemodynamic effects related to viscosity, hydrophilicity, ionicity, and CM pH.[1–3] CM may cause profound myocardial depression, which was observed to be more prolonged and more severe in the presence of coronary artery stenosis, presumably resulting in a longer exposure time of the contrast agent to the myocardial cell.[4] In addition, CM inhibits enzyme activity. It impairs the immune system, and it disturbs tissue microcirculation even causing ischemia from diminished blood pressure.[5] These effects may be mediated by the rapid increase in plasma osmolality following administration of hypertonic CM. High osmolality and associated chemotoxic effects of CM increase the content of free water in blood circulation, thus affecting intravascular volume and systemic vascular resistance. Osmolality may explain different hemodynamic effects of iso-osmolar contrast medium (IOCM) and low-osmolar contrast medium (LOCM). LOCM was reported to significantly decrease average renal blood flow[6] and affect heart rate and left ventricular end-diastolic pressure during coronary ventriculography and angiography.[7,8] Temporary decrease in blood pressure results in compensatory increase in heart rate and cardiac output. Self-limited episodes of hypotension may easily be missed when the blood pressure cannot be measured continuously. However, even short durations of intraoperative mean arterial pressure of <55 mm Hg may be associated with ischemia reperfusion injury, leading to sudden reduction in kidney function, serum creatinine increase, and increase in cardiac biomarkers.[9] Our preliminary data of anesthetized patients undergoing computed tomography (CT)-guided radiofrequency ablation (RFA) of liver lesions revealed a self-limited decrease in systolic blood pressure of >25 mm Hg following intravenous LOCM administration. To the authors' best knowledge, there are currently no clinical data on the extent and duration of hypotension following intravenous CM application, and it is not known whether it could reach clinically relevant levels. The purpose of this study was to systematically quantify the hemodynamic effects of intravenous CM application in patients under general anesthesia with continuous invasive blood pressure monitoring and to compare IOCM iodixanol and LOCM iopromide.

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The authors declare no conflicts of interest.

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METHODS

Study Design

We conducted a controlled, double-blinded, prospective, randomized phase IV clinical trial to compare 2 Food and Drug Administration–approved intravenous contrast

media, both of which are widely used for CT imaging in clinical routine. The study numbered AN2014-0218 339/2.2 was approved by the Institutional Ethics Committee, registered as clinical trial (EudraCT No: 2013-002051-15) and abided by the principles of the International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use (ICH) guidelines on Good Clinical Practice (GCP) (E6) recommended for adaptation by the ICH Steering Committee and the Declaration of Helsinki concerning the conduct, evaluation, and documentation of the study. Written informed consent was obtained from all subjects.

Participants

Patients having both radiological interventions with CM and continuous blood pressure measurement during general anesthesia were within the sampling frame of our study population. Consequently, we focused on patients with liver tumors undergoing RFA, in whom invasive blood pressure is measured routinely at our institution. The inclusion criteria for this study were adult patients >18 years of age considered for stereotactic RFA of primary and secondary liver tumors after approval by an interdisciplinary cancer board (American Society of Anesthesiologists score I–III), scheduled for radiological interventions with CM (mandatory administration) under general anesthesia. Exclusion criteria were patients with evidence of intolerance or previous allergic reactions to CM, estimated glomerular filtration rate <45 mL/min/1.73 m2 (Modification of Diet in Renal Disease Isotope Dilution Mass Spectrometry [MDRD-IDMS]), severe coronary artery disease, aortic valve disease, carotid artery stenosis, and patients who before anesthesia receive premedication other than midazolam (Dormicum; Roche Pharmaceutics, Vienna, Austria) orally 30 minutes prior to intervention at doses between 3.75 and 7.5 mg.

Investigational Medicinal Products

We used LOCM iopromide (Ultravist 370 mg I/mL; Bayer Austria Ges.m.b.H., Vienna, Austria) and IOCM iodixanol (Visipaque 320 mg I/mL; GE Healthcare Handels GmbH, Vienna, Austria) for contrast enhancement. Bioavailability and pharmacokinetic characteristics of the 2 investigational medicinal products (IMPs) are displayed in Table 1.

Table 1. Bioavailability and Pharmacokinetic Characteristics of Iopromide 370 and Iodixanol 320

Characteristics	Iopromide 370	Iodixanol 320
Property (mg J/mL)	370	320
Osmolality (mOsmol/kg water)	774	290
Viscosity at 37°C (mPa·s)	10	11.8
Density at 37°C (g/mL)	1.399	1.356
Potential of hydrogen (pH)	6.5–8.0	6.8–7.7
Maximum total dose (mL)	150	150
Main elimination half-life (h)	2	2.1
Plasma protein binding (%)	1	<1
Elimination route: renal, hepatic, etc	97% renal, 2% fecal	97% renal, 2% fecal
Renal clearance (mL/min)	106	110
Renal clearance/creatinine clearance (mL/min)	102	108

The characteristics are according to manufacturer's information provided in package insert by Bayer HealthCare Pharmaceuticals Inc and GE Healthcare Inc.

Randomization and Masking

The 2 different CMs to which individual patients were assigned were determined with a randomized schedule. Allocation ratio was 1:1. The randomization list was generated independently by the clinical investigator and sent to the staff responsible for labeling the IMPs. The randomization list was kept confidential and consulted only by the principal investigator for assignment on the day of treatment.

Patients and anesthesiologists were blinded. Blinding was performed by the attending radiologists. The IMP bottles were completely covered before the anesthesiologist entered the CT intervention room. Masking success was assessed by the radiologist.

Interventions

The intervention during which the study data were obtained followed the standard protocol for stereotactic radiofrequency ablation (SRFA).[10] The SRFA procedure is performed in anesthetized patients in whom a CM-enhanced CT scan is required for planning of the ablation, a nonenhanced CT scan is obtained for verification of proper needle placement, and after ablation another CM-enhanced CT scan is performed for final verification of ablation size.[11–13]

CM was administered using an automatic injector at a flow of 3 mL/s via a separate peripheral temporary venous catheter with single access using 80–150 mL (2× bodyweight, minimum 80 mL, maximum 150 mL). For each patient, normal saline solution (NSS) was administered by automatic injector during the nonenhanced CT scan as a placebo control using exactly the same dose and injection rate as the previously given CM. NSS was chosen as control to produce a volume effect similar to that of the substance tested, thus fulfilling the criteria of an active placebo.

Anesthesia. All patients received oral premedication with midazolam (Dormicum; Roche Pharmaceutics) 30 minutes prior to intervention at doses between 3.75 and 7.5 mg. Standard anesthetic induction procedure was achieved by administering fentanyl 3 to 4 µg/kg followed by propofol 2 to 3 mg/kg. Muscle relaxation for tracheal intubation was obtained with nondepolarizing rocuronium bromide with bolus 0.6 mg/kg. Rocuronium-induced neuromuscular block was maintained with repeated doses of 0.2 mg/kg at a train-of-four count of <10% using a peripheral nerve stimulator to assess the train-of-four twitch response. Maintaining a steady state of muscular tension was mandatory for needle positioning and was continued until proper placement of needles was confirmed by CT. Balanced anesthesia was maintained by combining the volatile anesthetic sevoflurane 1.5 to 2 vol% and the opioid remifentanil at infusion rates ranging from 0.08 to 0.1 µg/kg/min and increasing up to 0.3 µg/kg/min during heat application from RFA. In patients with a history of postoperative nausea and vomiting, total intravenous anesthesia was alternatively performed, eliminating the need for sevoflurane inhalation. Adequate hypnotic state was achieved with propofol 0.1 to 0.2 mg/kg/min. Remifentanil was administered at rates as mentioned above. Hypotension due to vasodilation and low cardiac output during induction and maintenance of

general anesthesia was counteracted with norepinephrine at infusion rates ranging from 0.03 to 0.05 µg/kg/min in all patients.

All patients were hydrated with crystalloid solution at a rate of approximately 5 mL/kg/h. Dehydration prior to the procedure was excluded by clinical investigation (skin and mucosal turgor, filling stage of neck veins, oliguria), blood pressure measurement, and blood gas examination. Current serum electrolyte levels were recorded as increased sodium concentration may aggravate peripheral vasodilation.

First CM bolus was administered about 60 minutes after induction of anesthesia and establishment of venous access, arterial line, urine catheter, and positioning on a vacuum mattress. Heart rate, invasive blood pressure (radial artery), and pulse oximetry were continuously measured during first administration of CM after planning CT, administration of NSS after placement of probes, and second administration of CM after completion of RFA. With the typical hemodynamic course following the bolus injection of CM and NSS, the following 4 reading points were recorded on our working chart:

1. Initial blood pressure (baseline value). The reading point was determined 1 minute before administration of CM and NSS.
2. Bolus administration of IOCM, LOCM, and NSS was followed by a slight rise in arterial blood pressure. The reading point was determined as the highest value.
3. In IOCM and NSS, the blood pressure returned to close to baseline whereas in LOCM the pressure declined significantly. The reading point was determined as the lowest value.
4. Following administration of IOCM, LOCM, and NSS (rebound value). The reading point was determined as the value 3 minutes after administration.

In addition, the interval between incipient decrease and return to the baseline blood pressure was charted.

Data were directly drawn from the anesthesia monitor (Datex Ohmeda Cardiocap; GE Healthcare, Madison, WI). Urine output was recorded hourly from the urinary catheter until the end of SRFA. Serum creatinine concentration was determined before and 48 hours after the intervention. Patient follow-up ended 48 hours after the intervention.

Outcomes

Primary study outcome was to quantify changes in systemic blood pressure, heart rate, and oxygen saturation before and after intravenous administration of either IOCM or LOCM. Relevant drops in systolic/diastolic arterial blood pressure were defined as >25/12.5 decline from baseline. Secondary outcome was to evaluate potential differences between intravenous administration of CM and the equivalent amount of NSS and to evaluate differences in per-hour urine output after CM administration.

Statistical Analysis

A sample size of 20 in each CM group gave 93% power to detect a decrease in systolic blood pressures >25 mm Hg, assuming a common standard deviation of blood pressure measurement below 22 mm Hg when using a 2-group t test with a 0.05 2-sided significance level. The H0 hypothesis was as follows: There is no difference in changes in systolic blood pressure between LOCM and IOCM. Standardized mean differences were calculated for comparison of baseline characteristics. Analysis of variance for repeated measurements together with t testing was applied for significance testing of the primary and secondary end points ($\alpha = .05$). Two-sided t test for paired values was used to compare between CM and NSS controls and between CM after first and second administration. In the case of deviations from normality or variance homogeneity assumptions, nonparametric testing was performed with the Mann-Whitney U test. All other statistical analyses were performed with appropriate descriptive statistical methods. Analysis was performed with SPSS, version 20 (IBM Inc, Armonk, NY). Statistical analyses were performed according to the intention-to-treat principle. No interim analysis was performed.

RESULTS

During November 18, 2014, and May 5, 2015, 50 patients were consecutively screened for eligibility, 40 of whom (20 LOCM, 20 IOCM) were included in the study (15 females, 25 males; mean age 61.79 years; range, 30–79 years). Eight patients were excluded by the exclusion criteria and 2 patients because the procedure could not be performed. All patients completed the study, and there were no follow-up losses (Figure 1). There were no CM-related adverse events. The baseline characteristics of participants in both CM groups were comparable (Table 2).

Arterial Blood Pressure

After administration of CM and NSS, systemic blood pressures showed a typical hemodynamic temporal course. Compared to the initial value obtained 1 minute before administration, systemic blood pressure first showed a slight increase, followed by a variable decrease and after 3 minutes recovery to initial and compensatory levels higher than initial (Figures 2 and 3). We did not alter the infusion or administer additional vasopressors so as to not skew the data.

Mean time from commencement of CM administration to decline in blood pressure was 65 ± 36 seconds for LOCM and 73 ± 43 seconds for IOCM. Time from onset of decline in blood pressure to normotension was 105 ± 61 seconds (range, 25–300 seconds) for LOCM and 112 ± 20 seconds (range, 90–145 seconds) for IOCM. A decrease in systolic blood pressures exceeding 25 mm Hg with systemic hypotension (systolic pressure <80 mm Hg) was observed only after LOCM administration (Table 3 and Figure 2). The mean systolic/diastolic pressure values after CM administration decreased to 79/43 mm Hg for LOCM and 119/62 mm Hg for IOCM ($P < .001$). Twelve (60%) of the 20 patients in the LOCM group had systolic pressure <80 mm Hg and mean arterial pressure <55 mm Hg, with the lowest mean arterial pressure being 39 mm Hg. Compared to baseline values obtained 1 minute before CM administration, LOCM resulted in a mean systolic/diastolic decrease of 31/16 mm Hg. Statistically significant differences in systolic and diastolic blood pressure values were found for time (systolic pressure $P < .001$, diastolic pressure $P < .001$), time × group

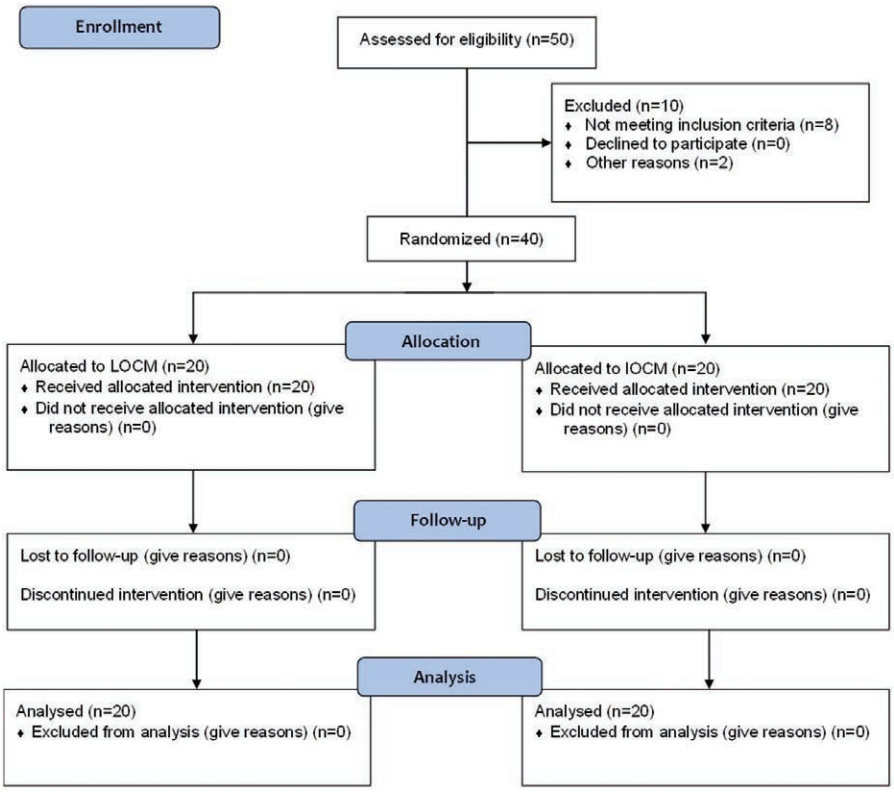

Figure 1. Consort flow diagram of the progress through the phases of randomized enrollment, intervention allocation, follow-up, and data analysis. IOCM indicates iso-osmolar contrast medium; LOCM, low-osmolar contrast medium.

Table 2. Comparison of Baseline Characteristics (Mean, ± Standard Deviation and Range) Between LOCM and IOCM Treatment Group

	LOCM (n = 20)	IOCM (n = 20)	Standardized Mean Differences
Gender (female)	7	9	0.205
Age (y)	62.5 ± 10.3 (32–75)	61.1 ± 12.4 (30–79)	0.066
Weight (kg)	83.8 ± 20.5 (55–133)	84.0 ± 25.1 (42–149)	0.005
Height	172.1 ± 6.5 (159–182)	173.1 ± 9.4 (156–190)	0.062
Body mass index (kg/m^2)	28.1 ± 5.5 (19–41)	27.6 ± 6.0 (17–42)	0.045
Heart rate (/min)	76.4 ± 16.3 (59–117)	76.6 ± 13.0 (54–108)	0.008
Systolic pressure (mm Hg)	137.5 ± 20.7 (113–181)	131.2 ± 17.9 (100–166)	0.162
Diastolic pressure (mm Hg)	85.1 ± 12.5 (66–105)	79.9 ± 10.1 (60–100)	0.225
Na (mmol/L)	139.8 ± 2.1 (136–143)	139.0 ± 2.4 (131–142)	0.179
K (mmol/L)	4.1 ± 0.3 (3.7–4.6)	4.1 ± 0.4 (3.6–4.9)	0.038
Creatinine (mg/dL)	0.9 ± 0.2 (0.5–1.3)	1.0 ± 0.3 (0.5–1.5)	0.150
Urea (mg/dL)	26.9 ± 12.2 (4–52)	33.5 ± 11.7 (12–53)	0.265

Abbreviations: IOCM, iso-osmolar contrast medium; LOCM, low-osmolar contrast medium.

interaction (systolic pressure $P < .001$, diastolic pressure $P < .001$), and group comparison (systolic pressure $P = .002$, diastolic pressure $P = .012$).

No statistically significant differences in systemic blood pressure were observed between the first and the second CM administration for either LOCM or IOCM.

Administration of NSS demonstrated a slight initial rise in systemic blood pressure similar to that for CM ($P > .640$; Figure 3). Comparing the lowest values following LOCM and NSS administration, statistically significant differences in systolic (28 ± 17 mm Hg; $P < .001$), diastolic (12 ± 6 mm Hg; $P < .001$), and mean arterial pressure (18 ± 9 mm Hg; $P < .001$) were detected. Three minutes after administration, systemic pressures were seen to have increased significantly more for LOCM, with differences of 9 ± 16 ($P = .013$), 4 ± 7 ($P = .013$), and 6 ± 11 mm Hg ($P = .024$), respectively.

Heart Rate

Heart rate measured when systemic blood pressure was at its lowest showed 62.9 ± 11.7 bpm in the LOCM versus 55.7 ± 10.3 bpm in the IOCM group ($P = .042$). Compared to baseline values 1 minute before CM application, LOCM resulted in a median (interquartile range) increase in heart rate of 4 (2–11) bpm and IOCM of 1 (1.5–3.5) bpm ($P = .043$).

Oxygen Saturation

Under inspiratory oxygen flow of 0.35 to 0.45 fraction of inspired oxygen (F_{IO_2}) peripheral saturation showed differences of 1% ± 2%, as measured when systemic blood pressure was at its lowest. There were no statistically significant differences between LOCM and IOCM with regard to oxygen saturation.

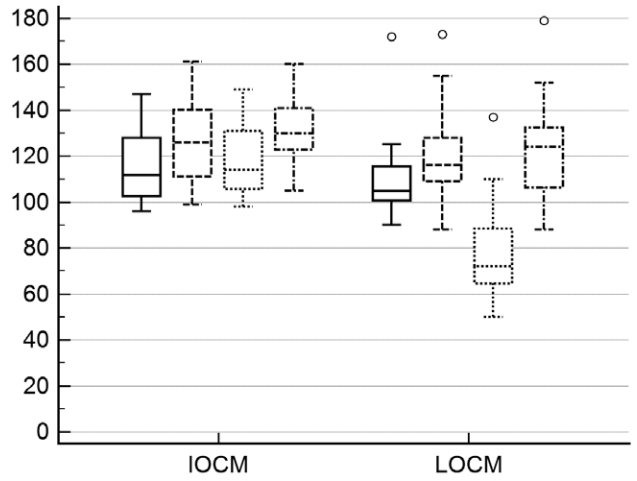

Figure 2. Box-plot comparison of systolic blood pressure (mm Hg) between the low-osmolar contrast medium (LOCM) and the iso-osmolar contrast medium (IOCM) treatment group showing the baseline value 1 minute before CM administration (—), the highest (- -) and lowest value (···) after CM administration and the rebound value 3 minutes after CM administration (-·-).

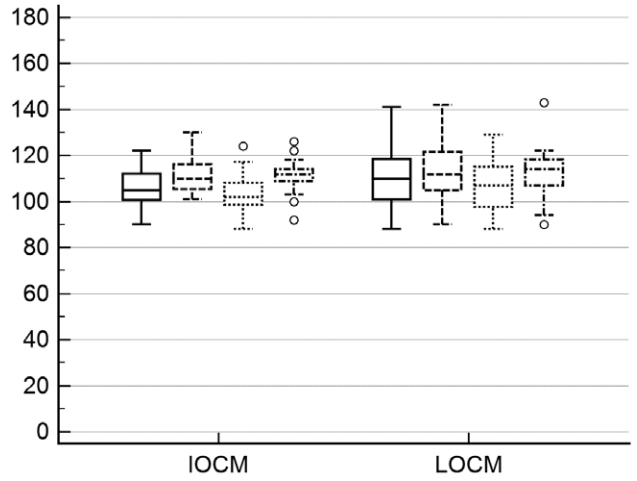

Figure 3. Box-plot comparison of systolic blood pressure (mm Hg) between the low-osmolar contrast medium (LOCM) and the iso-osmolar contrast medium (IOCM) treatment group showing the baseline value one minute before normal saline solution (NSS) administration (—), the highest (- -) and lowest value (···) after NSS administration and the rebound value 3 minutes after NSS administration (-·-).

Per-Hour Urine Output

Urine output was higher after administration of LOCM as compared to IOCM (P = .006). Median per-hour urine output (interquartile range) related to body weight was 3.7 (1.7–4.4) mL/h/kg in the LOCM group and 1.8 (0.7–2.3) mL/h in the IOCM group (P = .010). Forty-eight hours after treatment, no significant differences were seen in serum creatinine concentration (P = .541).

DISCUSSION

The main findings of this study highlight the self-limited decrease in arterial blood pressure following administration of LOCM. Compared with the baseline value obtained 1 minute before administration, LOCM resulted in a mean systolic/diastolic decrease of 31/16 mm Hg.

Average heart rate and rise in heart rate were more pronounced following LOCM administration, presumably due to a compensatory reaction to hypotension. Svensson et al[14] published an average heart rate and heart rate variation of 64.0 and 4.4 bpm after LOCM and 59.6 and 1.4 bpm after IOCM, which are well comparable with our results.

Intraoperative hypotension defined as any episode of systolic blood pressure <80 mm Hg or at least 1 episode of systolic blood pressure >20% below baseline was observed in 60% of our patients.[15]

Clinical relevance of these findings may arise from the fact that anesthesiologists working in the radiology department have to be aware of potential side effects of CM with regard to intolerance, organ function, and perfusion that might necessitate postoperative observation. In addition, anesthetists and radiologists should be aware of these effects in patients in whom episodes of disturbed tissue microcirculation may pose a clinical risk. In particular, elderly patients with a medical history of severe cardiac disease and renal dysfunction have an increased risk for mortality due to adverse CM reactions.[16,17]

Duration of intraoperative intervals of hypotension directly correlates with adverse cardiac- and renal-related outcomes.[9] Even 1 to 5 minutes of intraoperative mean arterial pressure <55 mm Hg can be clinically relevant with adjusted odds ratios of 1.18 for acute kidney injury, 1.30 for myocardial injury, 1.35 for cardiac complication, and 1.16 for 30-day mortality.[9] In our study, mean blood pressure <55 mm Hg was observed in 12 of the 20 patients following LOCM administration, with the lowest mean pressure of 39 mm Hg and the interval between decrease and return to baseline blood pressure lasting up to 300 seconds (105 ± 61 seconds).

Bach et al[18] observed a significant reduction in blood flow velocity in downstream capillaries as early as 10 seconds after administration of iopromide 370. The maximum effect was seen 30 seconds after administration, and it subsided within 120 seconds. This observation corresponds with our clinical findings, but cannot be explained solely by viscosity of the given CM. LOCM decreases tissue oxygen tension, and myocardial partial pressure of oxygen in the left coronary artery declines significantly after administration of iopromide 370.[5] Changes in erythrocyte morphology, for example, echinocyte formation, can contribute to diminished capillary blood flow.[19] Furthermore, buckling of venous endothelial cells within 90 seconds of exposure to iopromide 370 can significantly diminish venous blood flow.[20] We hypothesize that the self-limited significant drops in arterial blood pressure observed in our study are caused by temporary morphologic and functional changes in blood and endothelial cells immediately after LOCM administration. However, additional interactions via nitrous oxide, prostacyclins, or endothelin-1 have to be taken into account.[21]

In a recent meta-analysis, 3 studies showed a strong association between in-hospital cardiovascular events and administration of LOCM.[22] In cardiac high-risk patients with a history of acute myocardial infarction, unstable angina, and/or myocardial ischemia following myocardial infarction, Davidson et al[23] reported 45% fewer major adverse cardiac events when using IOCM during percutaneous transluminal coronary angioplasty. Arrhythmia was

Table 3. Comparison of Mean ± SD and Systolic, Diastolic, and Mean Arterial Pressures Between the LOCM and the IOCM Treatment Group

	LOCM (n = 20)	IOCM (n = 20)	*P*
Systolic blood pressure (mm Hg)			
Baseline value 1 minute before CM	109.5 ± 17.6 (90–172)	117.2 ± 16.6 (96–147)	.153
Highest value after CM	119.5 ± 19.1 (88–173)	127.8 ± 17.8 (99–161)	.154
Lowest value after CM	78.6 ± 19.9 (50–137)	119.0 ± 15.5 (98–149)	.000[a]
Rebound value 3 minutes after CM	121.7 ± 21.6 (88–179)	131.6 ± 15.0 (105–160)	.682
Diastolic blood pressure (mm Hg)			
Baseline value 1 minute before CM	59.3 ± 10.5 (41–90)	61.9 ± 9.6 (40–75)	.422
Highest value after CM	63.7 ± 10.4 (45–91)	64.9 ± 7.7 (49–77)	.663
Lowest value after CM	43.1 ± 9.0 (33–70)	61.9 ± 7.3 (43–76)	.000[a]
Value 3 minutes after CM	62.3 ± 11.4 (38–87)	66.4 ± 9.6 (49–88)	.312
Mean blood pressure (mm Hg)			
Baseline value 1 minute before CM	77.2 ± 13.9 (54–124)	83.0 ± 9.8 (65–100)	.132
Highest value after CM	82.2 ± 15.0 (49–125)	88.7 ± 10.1 (69–104)	.106
Lowest value after CM	56.7 ± 12.2 (39–92)	83.2 ± 9.3 (56–95)	.000[a]
Rebound value 3 minutes after CM	84.1 ± 15.5 (56–125)	91.2 ± 8.7 (76–110)	.450

Data shown are the baseline value 1 minute before CM administration, the highest and lowest value after CM administration, and the rebound value 3 minutes after CM administration.

Abbreviations: CM, contrast media; IOCM, iso-osmolar contrast medium; LOCM, low-osmolar contrast medium.

[a]*P* < .001.

more frequently observed.[14] In animal studies, drop in myocardial oxygen partial pressure and recovery intervals were observed to last considerably longer following LOCM than following IOCM.[5,24] Wysowski and Nourjah[17] observed that most deaths attributed to x-ray CM were associated with renal failure or nephropathy, anaphylaxis, and allergic reactions. Ten percent were related to cardiopulmonary arrest, 8% to respiratory failure, and 4% to stroke and cerebral hypoxia.[17] The hemodynamic effects of CM may play a contributing role in adverse reactions and complications.[17]

In our study, LOCM showed a significant diuresis with a 2-fold higher per-hour urine output than IOCM. We attribute this finding to the physiologic osmotic diuretic effect of low-osmolar contrast media. Serum creatinine 48 hours after the intervention was unaffected by the use of either CM.

Limitations

The number of patients was rather small, but the differences in the analyzed end points were highly significant. We cannot tell whether results from iopromide administration differ from other LOCMs.

The repeated measures design of our study stipulated CM-enhanced CT scan twice, before planning of the ablation and for final verification of ablation size in each patient. NSS was administered during nonenhanced CT scan for verification of proper needle placement. This sequence of treatments allowed investigations without alterations of the SRFA treatment procedure. Hypothetically speaking, the washout period between treatments could have induced a carryover effect and impairment of kidney function caused by the first CM administration could have altered the volume effects of NSS with regard to duration and intensity. However, we did not observe significant differences between the first and the second application of CM and between NSS in both groups.

Hypotensive effects of anesthesia can prolong the circulation time and increase duration of exposure to CM. We cannot exclude that differences between dosing of sevoflurane and propofol might have affected the hemodynamic profile of patients.

In our study, effects of general anesthesia on blood pressure were counteracted with very low-dosed continuous norepinephrine infusion right from the beginning in all patients. We cannot exclude that increased peripheral vascular resistance by norepinephrine might have altered the hemodynamic changes following contrast.

The results were obtained in patients under general anesthesia who were normotensive and may not be extrapolated to the clinical condition of nonanesthetized humans who are hypotensive. Furthermore, the study population was composed of patients with liver disease. We cannot tell whether CM-related hemodynamic effects differ from those in patients without liver disease.

CONCLUSIONS

This is the first randomized controlled prospective evaluation of hemodynamic effects following intravenous administration of LOCM and IOCM in patients under general anesthesia. LOCM produced a self-limited systemic hypotension and rise in heart rate that was statistically significantly different from that of IOCM. In light of the increasing number of radiologic interventions performed under general anesthesia, anesthetists and radiologists should be aware of these effects during CM-enhanced CT scans, especially in selected patients in whom short episodes of hypotension may pose a high clinical risk.

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DISCLOSURES

Name: Gerlig Widmann, MD.
Contribution: This author was the principal investigator and helped conceive and design the work, interpret the data for the work, draft the work, and finally approve the work.
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Contribution: This author was the co-investigator and helped design the work, interpret the data in the work, critically revised the work, and finally approve the version.

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Contribution: This author was the co-investigator and helped conceive and design the work, interpret the data for the work, draft and revise the work, and finally approve the work.
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