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Does Central Venous Oxygen Saturation-directed Fluid Therapy Affect Postoperative Morbidity after Colorectal Surgery?

A Randomized Assessor-blinded Controlled Trial

Ib Jammer, M.D.,* Atle Ulvik, M.D., Ph.D.,* Christian Erichsen, M.D., Ph.D.,† Olav Lødemel, M.D.,‡ Gro Østgaard, M.D., Ph.D.*

ABSTRACT

Background: The optimal amount and method for monitoring intravenous fluid in surgical patients is unresolved. Central venous oxygen saturation (Scv_{O_2}) has been used to guide therapy and predict outcome in high-risk and intensive-care patients. The aim of this prospective, randomized trial was to compare the rate of postoperative complications in patients receiving fluid therapy guided by Scv_{O_2} and those treated with a traditional effluent fluid scheme.

Methods: Patients undergoing open colorectal and lower intestinal surgery (n = 241) were randomized to the Scv_{O_2} group or the control group. The Scv_{O_2} group received perioperatively crystalloid infusion 100 ml/h. When Scv_{O_2} was less than 75%, a bolus of 3 ml/kg hydroxyethyl starch was given. The bolus was repeated if Scv_{O_2} increased by 1 percentage point or more. The control group was maintained with crystalloid 800 ml/h and given extra fluid if there were clinical signs of hypovolemia. The participating surgeon, unaware of the group allocation, registered complications within day 30.

Results: Until 8:00 AM on the first postoperative day, the Scv_{O_2} group had received 3,869 ± 992 ml (mean ± SD) intravenous fluid compared with 6,491 ± 1,649 ml in the control group. Increase in weight was 0.8 ± 1.8 kg and 2.5 ± 1.6 kg in the two groups, respectively. The postoperative complication rate was 42% in both groups.

Conclusion: Clinical outcomes among patients receiving Scv_{O_2}-guided perioperative fluid therapy were similar to those for patients treated with a traditional fluid regimen.

Limitations in study design prevent full interpretation of these findings, and further large trials of this treatment algorithm are still required.

What We Already Know About This Topic

- Whether restricted, goal-directed fluid administration improves outcomes is unclear.

What This Article Tells Us That Is New

- In patients undergoing elective open bowel surgery in whom a restricted fluid regimen guided by Scv_{O_2}, using colloid boluses compared with traditional crystalloid fluid administration, was used, there was no differences in the rate of perioperative complications despite significant differences in the quantity of fluid administered.

THE optimal amount of intravenous fluid for surgical patients is still vigorously debated.[1,2] The rationale behind the traditional liberal fluid regimen has been questioned. Recent studies with a restricted or an individualized, goal-directed fluid administration have shown better outcomes.[3–8] Because there is no simple way to predict who will respond to extra fluid by increasing cardiac output, a pragmatic approach is to observe the result of an intravenous bolus on a chosen target. Many of the studies on goal-directed fluid therapy have used a target derived from esophageal Doppler ultrasound, mostly stroke volume. This procedure is minimally invasive but requires expensive equipment and extensive training and has not gained widespread use in daily practice.

During anesthesia, when oxygen consumption is low and steady, it is reasonable to assume that central venous oxygen saturation (Scv_{O_2}) reflects cardiac output and oxygen supply. Scv_{O_2} may therefore be a useful physiologic indicator to

* Clinical Consultant, Department of Anaesthesia and Intensive Care, † Clinical Consultant, Department of Surgery, Haukeland University Hospital, Bergen, Norway. ‡ Clinical Consultant, Department of Anaesthesia, Voss Hospital, Voss, Norway.

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Address correspondence to Dr. Jammer: Department of Anaesthesia and Intensive Care, Haukeland University Hospital, Box 1 N-5021 Bergen, Norway. ib.jammer@helse-bergen.no.

guide fluid responsiveness and administration. After cardiac surgery, Scv_{O_2} correlated well with cardiac output after administration of fluid boluses.[9] In high-risk surgical patients, a low perioperative Scv_{O_2} was found to be a predictor of postoperative complications,[10,11] implying the possibility of improving outcome after surgery by treating low values.

Outcome studies for ordinary surgical patients receiving Scv_{O_2}-guided fluid therapy have not yet been published, but in high-risk patients, it may have shown a benefit.[12] In search for a low-cost fluid management strategy useful for daily practice, we conducted a prospective randomized trial in patients undergoing elective open bowel surgery. The aim of the study was to assess whether a restricted fluid regimen guided by Scv_{O_2} would reduce the rate of postoperative complications compared with our traditional fluid treatment.

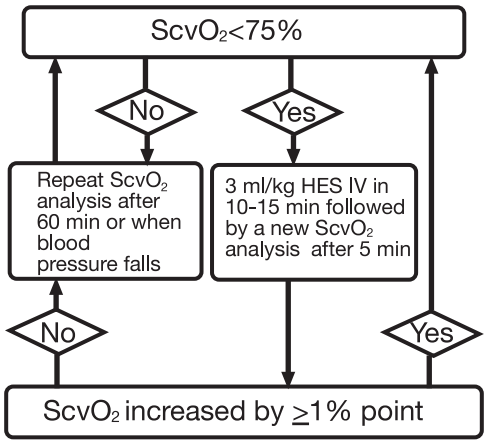

Fig. 1. Fluid algorithm for colloid boluses. HES = hydroxyethyl starch; Scv_{O_2} = central venous oxygen saturation.

Materials and Methods

Patients and Setting

Patients scheduled for elective open colorectal and lower intestinal surgery in a university and a municipal hospital of the same health trust were assessed for eligibility. Exclusion criteria were as follows: age less than 18 yr; inability to give informed consent; serum creatinine above 177 μM; serious stenotic, valvular heart disease; and receive anticoagulant therapy, the latter because large amounts of hydroxyethyl starch (HES) might increase the risk of epidural bleeding.[13] Patients were included consecutively whenever one of the investigating anesthesiologists was present.

Patients were randomized into two groups, Scv_{O_2}-guided fluid therapy (Scv_{O_2} group) or traditional fluid therapy (control group), immediately before induction of anesthesia. Randomization was performed by a web-based system developed and administered by the Unit of Applied Clinical Research, Norwegian University of Science and Technology (Trondheim, Norway). It was based on blocks of 8 to 20 patients and stratified for hospitals and for rectal surgery *versus* more proximal bowel surgery. The risk of complications was assumed to be higher in rectal surgery.[14]

The Scv_{O_2} group was treated with a low crystalloid fluid supply and additional colloid boluses guided by Scv_{O_2}. The control group had an effluent crystalloid volume based on estimated losses and maintenance, hemodynamic variables, and urine output.

The study was approved by the Regional Committee for Medical Research Ethics in Western Norway, University of Bergen, Bergen, Norway (ClinicalTrials.gov ID: NCT00468793), and written informed consent was obtained from all participants.

Scv_{O_2} Method

In the Scv_{O_2} group, a central venous line was inserted in the right internal jugular vein after induction of anesthesia. A blood sample was drawn for Scv_{O_2} analysis and processed immediately in a blood-gas analyzer (ABL 700; Radiometer, Brønshøy, Denmark; or Cobas b221; Roche, Basel, Switzerland). Daily error and reliability checks were performed by a trained lab technician in addition to the hourly self-calibration tests. Coefficient of variation for measurement of hemoglobin oxygen saturation is specified to 0.5%. A 75% Scv_{O_2} cut-off was chosen based on known physiologic data.[10,11,15] Further samples were taken and colloid boluses administered according to the flow chart shown in fig. 1. A mean arterial pressure below 60 mmHg would usually precipitate a new Scv_{O_2} analysis, but the exact limit was left to the anesthesiologist. After arrival to the recovery area, Scv_{O_2} was analyzed within 30 to 60 min, and a colloid bolus was given if saturation was less than 75%. If the patient displayed clinical signs of hypovolemia (*i.e.*, decline in blood pressure, urine output, and peripheral circulation), a sample was drawn and a bolus of fluid was given if Scv_{O_2} was less than 75%. The central venous line was removed the next morning (day 1).

Preoperative Management

Oral bowel preparation (sodium phosphate [Phosphoral®]; Casen-Fleet, Madrid, Spain) the afternoon before surgery was left to the discretion of the surgeon. Each patient was allowed to drink water until 2 h before surgery and was asked to empty his or her bladder. Every patient was weighed upon arrival in the operating theater. An epidural was inserted in a lower thoracic interspace. The catheter was tested and then maintained with a continuous infusion of bupivacaine 1 mg/ml, fentanyl 0.002 mg/ml, and epinephrine 0.002 mg/ml, usually at 8 ml/h with adjustments, if required, perioperatively and postoperatively. Pulse oximetry saturation (Sp_{O_2}) was recorded with the patient supine on the operating table. Standard monitoring included continuous electrocardiography, noninvasive arterial pressure, capnography, and pulse oximetry. We used invasive blood pressure only if indicated. Anesthesia was induced with thiopental or propofol, fentanyl, and vecuronium. The patients from the municipal hospital were maintained with propofol and remifentanil at continuous infusion, whereas most patients in the university hospital received isoflurane and fentanyl. Nitrous oxide was not used. The fraction of inspired oxygen was increased to

higher than 35% if needed to keep Spo_2 of at least 95%. Ventilation was adjusted to pco_2 30 to 37 mmHg. Patients were actively warmed with intravenous fluid warming and forced air, and temperature was maintained above 35.5°C. Low molecular weight heparin was given as thromboprophylaxis. The anesthesiologist decided when to transfuse blood or use a vasopressor. A bolus of ephedrine or metaoxedrine was the first choice; norepinephrine was used for continuous infusion.

Fluid Therapy

All patients received intravenous metronidazole 1,500 mg and doxycycline 400 mg or cephalothin 2 g as antibiotic prophylaxis. This administration implied approximately 800 ml crystalloid. The amount of fluids given on the day of operation (day 0) was summarized at 8:00 AM on day 1. Thereafter, intravenous fluid prescription was left to the surgeons, unaware of the patient's allocation.

Those assigned to the $Scvo_2$ group treated with a bowel preparation had 500 ml Ringer's acetate (Fresenius-Kabi, Halden, Norway) to compensate for the fluid deficit.[16] They were maintained on Ringer's acetate 100 ml/h. HES 130/0.4 60 g/l in 0.9% NaCl (Venofundin®; B Braun, Melsungen, Germany) was given as a 3 ml/kg bolus over 10 to 15 min if required according to the algorithm (fig. 1). To restrict crystalloid supply, bleeding was compensated by HES 1:1. Postoperatively, the patients had glucose 5% 80 ml/h and Ringer's acetate 1:1 only to replace losses on stomas or drains. Extra fluid was given if there were clinical signs of hypovolemia and $Scvo_2$ was less than 75%. Total HES supply was limited to 50 $ml \cdot kg^{-1} \cdot 24\ h^{-1}$.

The control group was managed according to a traditional fluid scheme,[17] (*i.e.*, 1,000 ml Ringer's acetate loading during the first hour in theater followed by approximately 800 ml/h (10–12 $ml \cdot kg^{-1} \cdot h^{-1}$)). The rate of infusion was increased if urine excretion dropped below 0.5 $ml \cdot kg^{-1} \cdot h^{-1}$ or the arterial pressure declined. The first 500 ml of bleeding was compensated for 1:4 by Ringer's acetate; bleeding of more than 500 ml was compensated for by 1:1 HES. HES was otherwise occasionally given perioperatively or postoperatively when considered necessary by the anesthesiologist as a result of a drop in blood pressure. Postoperatively, 5% glucose 1,000 ml was prescribed until the next morning, and extra fluid was given after clinical signs of hypovolemia.

Outcome

In the morning on day 1, after a period of at least 5 min without supplemental oxygen, Spo_2 was recorded by the attending nurse. Patients were weighed on the same electronic scale as before surgery by a physiotherapist or a nurse. If they were unable to stand upright, weighing later in the morning was tried once. A serum creatinine analysis was scheduled for postoperative day 3 and then recorded from the patient's chart.

Within 4 to 6 weeks, all but four patients had an ambulatory follow up in the hospital by the operating surgeon. The other four patients were followed-up with the use of a structured telephone interview by a nurse only. The postoperative status was routinely documented in the patient's chart. The participating surgeon registered postoperative complications from the patient's chart after follow up according to a predetermined and defined list of complications (table 1). These were chosen to have at least a possible connection with fluid management and most of them required interventions and/or treatment. The perioperative record data and the patient's group assignment were not immediately available and thus blinding was assured.

Statistical Analysis

The primary endpoint of the study was whether the patient had at least one postoperative complication within 30 days. Calculation of sample size was based on an anticipated 30% frequency of patients with one or more postoperative complications. To show a 50% reduction with 80% power at 5% significance level (two-sided), 119 patients had to be included in each group. Secondary endpoints were postoperative serum creatinine, Spo_2, and weight.

Data were analyzed in SPSS version 15.0 (SPSS Inc., Chicago, IL). Categorical outcomes were compared with the chi-square test, continuous variables with a two-sided *t* test, or the Mann–Whitney test for independent samples, as appropriate. *P* less than 0.05 was considered statistically significant. Odds ratio (OR) is reported as the odds of having an unfavorable outcome in the $Scvo_2$ group compared with control.

Results

From April 2007 to May 2009, 293 of 403 possible patients were approached and 241 patients were included in the study, 226 from the university hospital and 15 from the municipal hospital. One-hundred twenty-one patients were allocated to the $Scvo_2$ group and 120 to the control group (fig. 2). Five patients who had given consent were not randomized for one of the following reasons: investigating anesthesiologist was not available; rescheduled or postponed surgery; or inability to randomize because of data failure. In the $Scvo_2$ group, two patients had the surgical procedure converted after randomization—one to a stoma revision and another to laparoscopic surgery—and thus did not fulfill the inclusion criteria, and three patients had an explorative laparotomy instead of the planned procedure. The protocol had to be violated in two patients ($Scvo_2$ group) because of rhabdomyolysis in the legs after long-term exposure to the lithotomy position. They were successfully treated postoperatively with alkalization and 4–5 l noncolloid fluid to prevent renal damage. All patients were analyzed in their allocation groups based on intention to treat. In a few patients, secondary outcome variables were lost because of insufficient documentation (fig. 2).

Baseline Data

The groups were comparable in most parameters apart from age and type of surgery (tables 2 and 3). The median ages

Table 1. Complications (Definition) within 30 Days

	$Scvo_2$ Group (n = 121)	Control Group (n = 120)
Pulmonary		
Pneumonia (x-ray + antibiotics)	9	7
Pleural fluid (supplemental oxygen + x-ray)	7	5
Atelectasis (supplemental oxygen + x-ray)	6	6
Pneumothorax	0	1
Respiratory failure (intensive care treatment)	3	2
Pulmonary emboli (computed tomography + treatment)	0	1
Cardiac		
Arrhythmia (electrocardiogram + treatment or cardiologist consultation)	5	4
Coronary ischemia (electrocardiogram + troponin)	1	1
Pulmonary stasis/edema (x-ray or treatment)	1	0
Neurologic		
Postoperative delirium (treatment)	3	2
Focal neurological deficit	0	1
Infectious		
Wound infection (phlegmona + antibiotics or drainage)	20	16
Intraabdominal infection (computed tomography + antibiotics)	13	12
Central venous catheter infection	0	0
Wound rupture (operation)	5	5
Gastrointestinal		
Anastomotic leakage (antibiotics + drainage or laparotomy)	9	11
Mechanical ileus (operation)	1	1
Gastrointestinal bleeding (transfusion or gastroscopy)	2	2
Paralytic ileus (unable to tolerate enteral diet more than 5 days)	5	17
Others		
Renal impairment (creatinine increase more than 33%)	11	7
Impaired spontaneous voiding (catheterization more than two times)	12	11
Venous thrombosis (treatment)	1	0
Sum of complications	114	112
Patients with at least one complication, n (%)	51 (42.1)	51 (42.5)

(range) in the $Scvo_2$ and control groups were 58 (21–87) and 63 (25–91) yr, respectively. Colectomy due to inflammatory bowel disease was overrepresented in the $Scvo_2$ group, and only 5 patients older than 80 yr were recruited in this group compared with 15 in the control group. Estimated blood loss, number of patients given erythrocyte transfusions, and the duration of surgery did not differ significantly between the groups (table 3). All central venous catheters were placed in the superior vena cava, confirmed by postoperative x-ray. No complications were related to the central venous access.

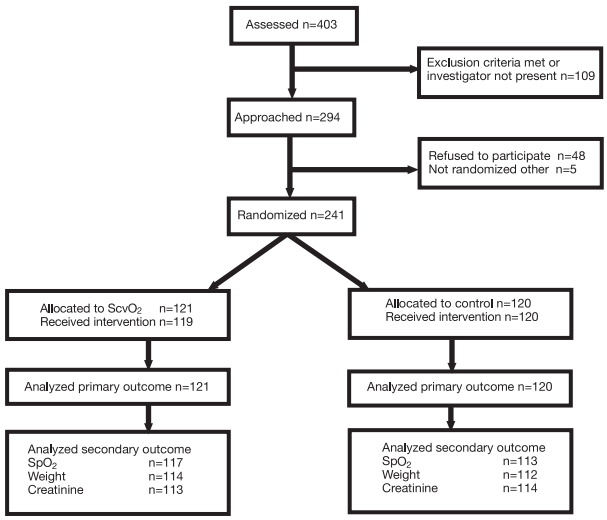

Fig. 2. Flow chart for patients' progression through the trial. $Scvo_2$ = central venous oxygen saturation; Spo_2 = pulse oximetry saturation.

Perioperative Fluid Supply

The $Scvo_2$ group had less total fluid on the day of operation than the control group (mean difference, 2622 ml; 95% CI, 2275–2968 ml), whereas the amount of colloid given was higher (table 4). The $Scvo_2$ group received 10.1 ml/kg (range, 0–30) HES, the control group 6.4 ml/kg (range, 0–29). The lower total fluid supply in the $Scvo_2$ group resulted in 76 ml (95% CI, 23–129 ml) less perioperative urine output. The calculated output per kilogram and hour includes urine in the bladder at the time of catheterization (table 4). The loss on stomas and drains was highly variable but similar in the groups.

Primary Outcome

The number of patients with one or more complications was equal in both groups (OR = 0.98 [95% CI, 0.6–1.6]) (table 1). There was no difference in the incidence of renal impairment defined as more than 33% increase in serum creatinine (OR = 1.6 [95% CI, 0.6–4.3]). In several patients, creati-

Table 2. Patient Characteristics

	$Scvo_2$ Group (n = 121)	Control Group (n = 120)	*P* Value
Female	53 (44)	49 (41)	0.64*
BMI, kg/m^2	25.1 (4.7)	25.2 (4.9)	0.86†
Age, yr	57 (15)	64 (13)	<0.001†
ASA class I/II/III, n	16/96/9	12/90/18	0.15*
POSSUM physiological, median (range)	15.0 (12–30)	17.0 (12–35)	0.08‡
Hemoglobin, g/dl	13.2 (1.8)	13.5 (1.8)	0.40†
Serum creatinine, μM	75(15)	75 (17)	0.85†
Smoker	18 (15)	26 (22)	0.17*
Pulmonary disease	18 (15)	22 (18)	0.47*
Heart disease	17 (14)	17 (14)	0.98*
Diabetes	7 (6)	7 (6)	0.99*
Diagnosis	—	—	0.07*
Cancer	85 (70)	99 (82)	—
Inflammatory bowel disease	27 (22)	14 (12)	—
Other	9 (7)	7 (6)	—
Bowel preparation	58 (48)	60 (50)	0.80‡

Data are presented as mean (SD) or n (%) unless otherwise noted.

* Chi-square test. † Two sample *t* test. ‡ Mann–Whitney test.

ASA = American Society of Anesthesiologists; BMI = body mass index; POSSUM = Physiological and Operative Severity Score for the Enumeration of Mortality and morbidity.

nine increased weeks after the operation because of large losses on stomas. No patient needed renal replacement therapy. Fewer patients in the $Scvo_2$ group had postoperative paralytic ileus (*i.e.*, 5 *vs.* 17; OR = 0.26 [95% CI, 0.09–0.73]). There were 12 reoperations in the $Scvo_2$ group and 14 in the control group. Five patients were treated in the intensive-care unit, mainly because of respiratory failure (table 1). At follow up within 4 to 6 weeks, the number of patients who reported that their wounds had not healed properly was 30 (of 121) in the $Scvo_2$ group *versus* 35 (of 116) in the control group (OR = 0.76 [95% CI, 0.43–1.35]). Mean length of stay in the hospital was 13.3 days in the $Scvo_2$ group *versus* 12.6 in the control group. Both groups had a median length of stay of 11 days (range, 5–63). No patients died within 30 days.

Secondary Outcome

The fluid load resulted in a mean weight gain of 0.8 ± 1.8 kg (mean ± SD) in the $Scvo_2$ group and 2.5 ± 1.6 kg in the control group ($P < 0.001$) (fig. 3). Excluding the two patients in the $Scvo_2$ group treated with forced diuresis (4.2 and 4.1 kg increase, respectively) reduced the mean weight gain to 0.7 ± 1.7 kg. The decline in Spo_2 on the first postoperative day was 2.0% in the $Scvo_2$ group and 2.8% in the control group, with a mean difference of 0.75% (95% CI, −0.07–1.58%), which was not signifi-

Table 3. Perioperative Management

	$Scvo_2$ Group (n = 121)	Control Group (n = 120)	*P* Value
Operative site proximal bowel/rectum	61/60	60/60	0.95*
Type of surgery			0.03*
Hemi- and sigmoid colectomy	35	35	—
Proctectomy and/or colectomy	20	5	—
Low anterior or rectal amputation	48	54	—
Extensive (other organs included)	3	7	—
Small bowel or explorative laparotomy	15	19	—
Duration of surgery, min	153 (71)	149 (65)	0.61†
Stoma sited, n (%)	62 (51)	47 (39)	0.06*
Estimated blood loss, ml, median (range)	200 (0–1,750)	250 (0–3,000)	0.11‡
Patients transfused erythrocytes (1–4 units)	12	10	0.65*
Patients given plasma (1–2 units)	2	1	0.37*
Hemoglobin postoperative day 1, g/dL	11.3 (1.4)	11.0 (1.5)	0.06†
Epidural not sited	5	1	0.10*
Vasopressor infusion, n (%)	31 (26)	21 (17)	0.12*

Data are presented as mean (SD) or n unless otherwise noted.

* Chi-square test. † Two sample *t* test. ‡ Mann–Whitney test.

Table 4. Fluid Balance

	$Scvo_2$ Group (n = 121)	Control Group (n = 120)	*P* Value*
Perioperative	—	—	—
Ringer's acetate, ml	649 (333)	2,743 (1,020)	<0.001
Other crystalloid, ml	773 (209)	694 (247)	0.008
HES 130/0.4, ml	438 (419)	285 (405)	0.004
Urine output, ml · kg^1 · h^{-1}	1.1 (1.5)	1.5 (1.5)	0.020
Postoperative until day 1, 8:00 AM	—	—	—
Ringers acetate, ml	138 (529)	1,363 (771)	<0.001
HES 130/0.4, ml	313 (328)	194 (333)	0.006
Other crystalloid, ml	216 (176)	242 (260)	0.379
Glucose 5%, ml	1,185 (344)	877 (282)	<0.001
Oral, ml	163 (250)	92 (152)	0.008
Urine, ml	831 (445)	1,104 (449)	<0.001
Loss stoma/drain, ml	144 (230)	151 (242)	0.815
Total fluid until day 1, 8:00 AM, ml	3,869 (992)	6,491 (1,649)	<0.001

Data are presented as mean (SD) unless otherwise noted.

* Two sample *t* test.

HES = hydroxyethyl starch.

cant ($P = 0.07$). Postoperative serum creatinine was higher in the $Scvo_2$ group than in the control group. When preoperative creatinine was subtracted from creatinine on day 3, the difference between groups was 5.6 μM (95% CI, 0.4–10.8 μM) ($P = 0.03$) (fig. 3).

Discussion

In this randomized controlled study of patients undergoing open colorectal and lower intestinal surgery, the rate of complications was the same whether fluid was given according to a traditional regimen or followed a restricted regimen supplemented by $Scvo_2$-guided optimization.

Intervention groups given less fluid have shown a better outcome after gastrointestinal surgery.[3,5,6] Evaporative losses may be less than formerly anticipated, and the concept of a third space has been questioned.[18,19] After 800 ml antibiotic fluid, we administered 100 ml/h Ringer's acetate perioperatively in our study group. With a mean 150 min duration of surgery, the sum of crystalloid is similar to a suggested maintenance rate of 6 mg · kg^{-1} · h^{-1} based on echocardiography in open colorectal surgery.[19] We thus managed to limit the amount of fluid compared with our traditional regimen in accordance with trials on fluid restriction.[3,5,6] In contrast to these studies, we found no benefit of a low-fluid regimen apart from a possible lower incidence of postoperative paralytic ileus in the group given less fluid, supporting the view that fluid overload might impair gastrointestinal motility.[5,20]

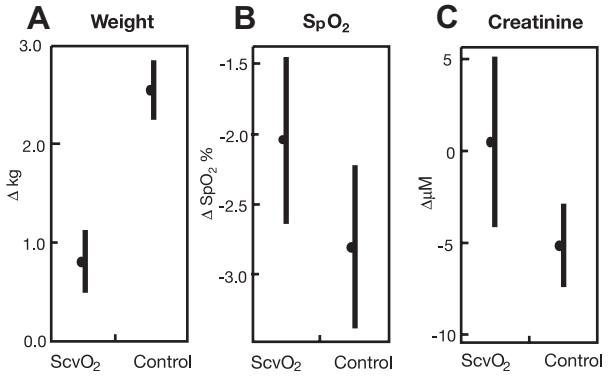

Fig. 3. Secondary outcome parameters in the two groups expressed as the difference between preoperative and postoperative values. (*A*) Weight gain at day 1. (*B*) Spo_2 decline at day 1. (*C*) Creatinine change at day 3 (mean with 95% confidence interval). Control = control group; $Scvo_2$ = central venous oxygen saturation group; Spo_2 = pulse oximetry saturation.

The control group had what some would define as a liberal, others an excessive, fluid supply.[1,3] The volume comprises anticipated evaporation, third space loss, maintenance, compensation for reduced cardiac filling as a result of vasodilation, and positive pressure ventilation plus extra fluid, as recommended when urine output or arterial pressure is low. The positive fluid balance following this strategy was reflected in 2.5-kg postoperative weight gain. A similar increase in weight from 1.9 to 2.8 kg has been reported in the high-volume groups in previous trials comparing high and low fluid supply.[5–7]

Bellamy has illustrated the association between the risk of adverse effects and fluid supply as a U-curve in a diagram where the y-axis represents postoperative morbidity and the x-axis the fluid load. Both too little and too much fluid would increase the rate of complications.[2] Bundgaard-Nielsen *et al.*[21] suggested that the shape of the U-curve may vary because of comorbidities and form a V-shape during critical illness, where titrating fluid to the nadir of the curve would be essential to reduce morbidity. In relatively healthy patients, the curve would look like a horizontal parenthesis with little difference in outcome whether fluid supply was optimal or not. This may explain why we found no difference in complication rate in our study.

The best documented method in recent years for goal-directed fluid therapy is esophageal Doppler ultrasound. Although meta-analyses seem to favor a beneficial effect on morbidity in gastrointestinal surgery,[3,4,22] most of these studies included a small number of patients, and the primary outcome was length of stay and not postoperative complications. The esophageal Doppler ultrasound method, however, is not without problems comprising cost, operator dependency, and need for training,[23] and an unresolved time to estimate a reliable stroke volume, especially in cases of arrhythmia.[22,24] It is inconvenient in awake patients and excluded in upper gastric and esophageal surgery. Other methods for goal-directed therapy are based on the arterial waveform. They are under investigation with only few outcome studies yet presented.[25] In search of an easily available method to individualize fluid therapy, and to secure that a low volume basal fluid infusion would not restrict cardiac output and oxygen supply perioperatively, we chose $Scv\overline{O}_2$ as the target variable.

Central venous oxygen saturation reflects oxygen extraction mostly in the head and upper part of the body. It cannot automatically replace mixed venous oxygen saturation. The relation between them changes in different pathologic conditions.[15,26] However, for most elective surgical patients, $Scv\overline{O}_2$ will change in accordance with mixed venous oxygen saturation. Pulmonary artery catheters are seldom indicated in gastrointestinal surgery.[27] We postulated therefore that $Scv\overline{O}_2$ could be a useful physiologic indicator to guide fluid therapy perioperatively in this group of patients.

We chose 75% $Scv\overline{O}_2$ as the goal, although there is not much $Scv\overline{O}_2$ data available in ordinary surgical patients to support that threshold for fluid supply. Extra fluid was supplied when a colloid bolus caused an increase in $Scv\overline{O}_2$ as a result of an increase in cardiac output. Jenstrup *et al.*[28] administered fluid before anesthesia and gastrointestinal surgery based on this principle and obtained a maximal $Scv\overline{O}_2$ of 71.5%. A 100-ml intravascular volume deficit was suggested to correspond to a 1% decline in $Scv\overline{O}_2$.[28,29] Donati *et al.*[12] used both fluid and inotropic therapy to obtain an oxygen extraction ratio corresponding to 73% $Scv\overline{O}_2$ during intra-abdominal surgery in high-risk patients. Because the amount of fluid in the groups was similar, the use of dobutamine in the intervention group may have been decisive for the reduction in the rate of organ failure from 30 to 12% in their study.[12] In high-risk surgical patients, $Scv\overline{O}_2$ lower than 73% predicted postoperative complications, and the authors encouraged prospective trials using $Scv\overline{O}_2$ as a therapeutic goal.[10] In the sepsis algorithm, 70% was chosen as the limit for $Scv\overline{O}_2$.[30] The benefit of setting a limit as we did, instead of maximizing the target for the individual patient, is unresolved. Our strategy resulted in 120 ml perioperative colloid (in addition to substitution for the bleeding) and a weight gain of 0.8 kg. Using a lower threshold in line with the referred studies on high-risk patients[10–12,30] would probably have resulted in even less fluid to the $Scv\overline{O}_2$ group.

Postoperative complications within 30 days have been reported to be a strong predictor of long-time survival.[31] Hence, this might be a more relevant outcome measure than the frequently used length of stay. A postoperative complication has been defined as "any deviation from the normal postoperative course."[14] The lack of standardization can explain why a variety of complications with highly variable frequency is reported in fluid-related studies regarding gastrointestinal surgery.[5,6,8] This makes an exact interpretation and evaluation of the outcome differences difficult. Minor complications such as postoperative nausea, vomiting, and urinary tract infections were not included in our study. The frequency of complications was nevertheless higher than the anticipated 30% complication rate from the power calculation, rendering it possible to detect at least a 42% decrease in rate of complications with 80% power.

HES is potentially nephrotoxic.[13] Because the restricted crystalloid supply and a high colloid load could increase the risk of renal damage,[32] we wanted to register all possible renal dysfunction. There is no consensus on a single criterion to define postoperative renal dysfunction, and serum creatinine may not be an ideal parameter.[33] Patients treated with the $Scv\overline{O}_2$ regimen had a higher serum creatinine on day 3 than the control group. This may reflect a higher strain on the kidneys, but the clinical importance is unclear. However, we could not demonstrate a higher frequency of renal impairment in the $Scv\overline{O}_2$ group within 30 days.

Our trial has several important limitations. Despite general and epidural anesthesia, muscle relaxants, and temperature control, fluctuations in oxygen uptake, which alters $Scv\overline{O}_2$, may occur perioperatively. Other possible confounders (*e.g.*, triggers for transfusion or vasopressor therapy) were not strictly defined. A regimen based on a restricted crystalloid supply with a goal-directed fluid administration strategy was compared with our traditional regimen. Thus, blood loss was compensated for differently in the groups. Accordingly, like many other goal-directed studies, more colloid was used in the intervention group.[4,8] In our study, the mean difference between the groups was 4 ml/kg. Apart from staying mostly in the intravascular compartment causing less edema than crystalloids, HES has been claimed to have other positive effects (*e.g.*, reducing neutrophil adhesion to the endothelial cell layer).[13] The clinical importance is unresolved, and this potential benefit was not reflected in a better outcome in the $Scv\overline{O}_2$ group. Neither was the possible advantage of lower mean age in this group. There are no standard criteria for assessment of postoperative complications. We registered in retrospect, not at a fixed time point, a predefined set of complications that occurred before day 30. Although we used data from the patient's chart, collected by the clinical team, and therefore believe we detected all important complications, this approach remains subjective and may not be sufficiently robust for a randomized trial of a clinical intervention.

In conclusion, patients receiving fluid therapy aimed at $Scv\overline{O}_2$ of at least 75% did not achieve a more favorable outcome after gastrointestinal surgery than patients treated with a traditional fluid regimen. It is noteworthy that the volume

of intravenous fluid administered was less in the Scv_{O_2} group. If goal-directed fluid therapy is a key issue in reducing complications after bowel surgery in ordinary patients, this trial cannot support Scv_{O_2} with a target of at least 75% as a recommended strategy for fluid administration. Whether a larger study may detect a smaller reduction in complications, or if it may be better to maximize Scv_{O_2} rather than setting an upper limit, remain to be shown.

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ANESTHESIOLOGY REFLECTIONS

The Rider Tavern by Vandam

Home today to the Charlton Historical Society of Massachusetts, the Rider Tavern stands as "one of the least altered and best documented examples of a wayside tavern of the Federal period in New England." Such "public" taverns (now "pubs" in Old England) demonstrated more open architecture than security-conscious "bars," where portcullis-like security bars were lowered or positioned to protect stashes of alcoholic beverages. Some 22 yr after construction had begun on Rider Tavern, ether pioneer W. T. G. Morton was born nearby in 1819. Five years later, during an 1824 visit as a guest of U.S. President James Monroe, the Marquis de La Fayette inspected his fellow Revolutionary War veterans as they mustered outside Rider Tavern. A later visitor, a retired Editor of ANESTHESIOLOGY, Leroy D. Vandam, M.D. (1914–2004), memorialized the landmark (*see above*) as *The Rider Tavern*, a watercolor acquired by the Wood Library-Museum in 1993. (Copyright © the American Society of Anesthesiologists, Inc. This image appears in color in the *Anesthesiology Reflections* online collection available at www.anesthesiology.org.)

George S. Bause, M.D., M.P.H., Honorary Curator, ASA's Wood Library-Museum of Anesthesiology, Park Ridge, Illinois, and Clinical Associate Professor, Case Western Reserve University, Cleveland, Ohio. UJYC@aol.com.