ORIGINAL ARTICLE

Total intravenous general anaesthesia vs. spinal anaesthesia for total hip arthroplasty: a randomised, controlled trial

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Conflicts of interest
None declared.

Funding
The study was supported with institutional grants

Submitted 25 September 2014; accepted 24 October 2014; submission 16 2014.

Citation
Harsten A, Kehlet H, Ljung P, Toksvig-Larsen S. Total intravenous general anaesthesia vs. spinal anaesthesia for total hip arthroplasty: a randomised, controlled trial. Acta Anaesthesiologica Scandinavica 2015

doi: 10.1111/aas.12456

Background: The choice of anaesthetic technique for patients undergoing joint arthroplasty is debatable. The hypothesis of this study was that general anaesthesia would generate a more favourable recovery profile than spinal anaesthesia.
Methods: We randomly allocated 120 patients to either intrathecal bupivacaine or general anaesthesia with target-controlled infusion of remifentanil and propofol. Length of hospital stay assessed as meeting discharge criteria was the primary outcome parameter. Other outcome parameters were actual time of discharge, pain, use of rescue pain medication, blood loss, length of stay in the post-operative care unit, dizziness, post-operative nausea, need of urinary catheterisation and patient satisfaction.
Results: General anaesthesia resulted in slightly reduced length of hospital stay (26 vs. 30 h, $P = 0.004$), less nausea ($P = 0.043$) and dizziness ($P < 0.001$). General anaesthesia patients had higher pain scores during the first two post-operative hours ($P < 0.001$) but lower after 6 h compared with the spinal anaesthesia group ($P < 0.01$ and $P < 0.05$). General anaesthesia patients had better orthostatic function compared with spinal anaesthesia patients ($P = 0.008$). Patients in the spinal anaesthesia group fulfilled the discharge criteria from the post-operative care unit earlier compared with the general anaesthesia patients ($P = 0.004$). General anaesthesia patients requested a change in the method of anaesthesia for a subsequent operation less often than the spinal anaesthesia patients (5 vs. 13, $P = 0.022$).
Conclusion: General anaesthesia resulted in a more favourable recovery profile compared with spinal anaesthesia.

Editorial comment: what this article tells us
During fast-track hip arthroplasty, general anaesthesia with propofol-remifentanil compared with spinal anaesthesia may enable a shorter post-operative hospital stay. Similarly, the overall recovery profile for propofol-remifentanil demonstrates faster ambulation with less dizziness and better orthostatic function, despite initially higher post-operative pain scores, than following spinal anaesthesia.

Acta Anaesthesiologica Scandinavica
AN INTERNATIONAL JOURNAL OF ANAESTHESIOLOGY AND INTENSIVE CARE, PAIN AND EMERGENCY MEDICINE

Total hip arthroplasty (THA) is a frequently performed and painful procedure.[1] It is in most cases carried out using general anaesthesia (GA) or regional anaesthesia. Among the various regional techniques, spinal anaesthesia (SA) is not only common, but also recommended.[2] Without question, SA will produce excellent pain control in the early post-operative phase, but will this advantage remain longer or could a modern GA technique be preferable in a fast-track set-up? Thus, most studies have not compared SA with GA using propofol and remifentanil with multimodal opioid-sparing analgesia and a fast-track setup.

In a previous study, it was shown that GA with propofol-remifentanil may be advantageous in terms of earlier recovery; reduced pain, nausea and dizziness scores; and earlier ability to walk compared with SA for patients undergoing fast-track total knee arthroplasty.[3] In addition, the patients preferred GA to SA in case of a new total knee arthroplasty.[3] The hypothesis of the present study was that GA would result in more favourable recovery effects after THA compared with SA.

Consequently, we did a prospective, randomised trial to compare SA and GA with regard to length of hospital stay (LOS) and comfort factors such as opioid requirements, pain, dizziness and total anaesthesia satisfaction for patients undergoing THA.

Methods

The study was approved by the Research Ethics Committee at Lund University (no 2012/659, 13 December 2012) and was carried out at Hässleholm Hospital, Sweden. It was registered at http://www.clinicalTrials.gov (reg. no NCT01733472, 20 November 2012). All patients gave their written informed consent prior to participating in the study. The study was conducted in accordance with the Declaration of Helsinki and conformed to the CONSORT guidelines.[4,5]

Study design

The design of the study was consecutive and randomised. Patients at the Hässleholm Hospital, Sweden, with osteoarthritis scheduled for THA were eligible for participation in the study. LOS assessed as meeting discharge criteria was the primary outcome parameter. Other outcome parameters were actual time of discharge, pain, use of rescue pain medication, blood loss, length of stay in the post-operative care unit (PACU), dizziness, post-operative nausea, need for of urinary catheterisation and patient satisfaction.

Inclusion criteria were ASA I-III (American Society of Anesthesiologists physical status), able to understand the given information, age > 45 years and < 85 years and having signed the informed consent document. Exclusion criteria were previous surgery to the same hip, obesity (body mass index > 35), rheumatoid arthritis, immunological depression and allergy to any of the drugs used in this study. Patients were also excluded if they were taking opioids or steroids or if they had a history of stroke or psychiatric disease that potentially could affect the perception of pain.

Randomisation and blinding procedure

Patients were randomised by a nurse, not involved in the study, who prepared envelopes containing information on which of the two anaesthetic methods the patient should receive (GA or SA). Patients and staff were blinded to which of the treatments each patient was allocated to until 1 h prior to surgery. From this time and until the patient reached the PACU, both patients and personnel in the operation theatre were, for obvious reasons, aware of the method of anaesthesia being used. Once the patients left the operating theatre, all personnel who were involved in the study were blinded as to what treatment was given. This was carried out by asking a nurse who was not involved in the care of the present study patient to do the evaluation.

Anaesthesia and perioperative care

One hour before surgery, the patients were given oral celecoxib 400 mg and paracetamol 1 g. Thereafter, 200 mg celecoxib was administered every 12 h, and 1 g paracetamol every 6 h. None of the patients received an indwelling urinary catheter prior to surgery. No drains were used.

A standardised administration of intravenous infusion of Ringer's acetate of 500 ml was given prior to anaesthesia induction. After that, a rate of 2.5 ml/kg/h was given to all patients during the

surgery. To compensate for blood loss during surgery, up to 500 ml of hydroxyethyl starch (Venofundin®, Braun, Crissier, Switzerland) was used. Tranexamic acid 1 g was administered i.v. to all patients. Patients in the SA group received intrathecal (L_4–L_5) anaesthesia (using a 25-G Quinke needle, Spinocan®, B.Braun AG, Melsungen, Germany) consisting of isobaric bupivacaine 0.5%, 3 ml. An infusion of propofol 10 mg/ml was administered to induce light sedation during surgery. All patients were breathing spontaneously with supplemented oxygen 2 l/min.

Patients in the GA group were anaesthetised using target-controlled infusion (TCI) with remifentanil 40 μg/ml and propofol 10 mg/ml using the pharmacokinetic models described by Marsh et al. and Minto et al.[6,7] The computer-controlled infusion pumps were set on an initial target plasma concentration of 5 ng/ml for remifentanil and 5 μg/ml for propofol. To facilitate intubation rocuronium bromide, 0.6 mg/kg was given. Ventilation was performed with oxygen/air and aimed at $EtCO_2$ 4.5 kPa. Glycopyrronium 0.5 mg and neostigmine 2.5 mg were given at the end of the surgery. At 20 min before the end of the surgery, oxycodone (OxyNorm®) 10 mg i.v. was given.

All patients received cloxacillin 2 g i.v. (or clindamycin 600 mg i.v. in case of penicillin allergy) prior to surgery. No anti-emetic medication was given prior to surgery. The pre-operative fasting period was 6 and 2 h before surgery for solid food and clear fluids, respectively.[8]

All patients were pre-operatively familiarised with a patient-controlled analgesia (PCA) device for post-operative pain medication during the first post-operative 24 h. An Abbott GemStar PCA Pump (Abbott Laboratories, North Chicago, IL, USA) was used, and it administered i.v. doses of morphine 20 μg/kg with a lock out time of 10 min.[9] Morphine was used in the PCA pump because this drug has been used in previous studies and would therefore make comparison with other studies easier. The PCA pump was attached to the patients as they left the operating room (OR). After 24 h, the pump was removed and the amount of morphine administered was noted. Furthermore, the number of administered and requested, but not administered PCA, doses were registered together with the time at which these doses were requested. After 24 h, oxycodone (OxyNorm®) 10 mg orally was administered as required by the patients in both groups as rescue pain medication.

To prevent overdistension of the urinary bladder, ultrasound scans were done at least every third hour until the patients had spontaneous micturition. The policy for ultrasound scans of the bladder were:

1. bladder volume < 300 ml, repeat bladder scan within 3 h
2. 300–399 ml repeat the bladder scan within 2 h
3. 400–499 ml repeat the bladder scan within 1 h
4. ≥ 500 ml perform an intermittent catheterisation. This manoeuvre could be repeated twice after which an indwelling urinary bladder catheter is used.

Assessments

The patients were familiarised with a visual analogue scale (VAS; 100 mm) used for assessment of pain (0 = no pain, 100 = worst imaginable pain), post-operative nausea and vomiting (PONV) and dizziness (0 = no symptom, 100 = worst symptom possible).

Pain was recorded pre-operatively, on arrival to PACU and then after 2, 4, 6 and 10 h. The first (POD1) and second (POD2) day after surgery, pain was registered at 8 and 14 h. Pain was assessed at rest, with 45° knee flexion, with the knee straight and 45° hip flexion and after walking 5 m.[10]

Dizziness (and at the same time blood pressure) was registered 5 h after the end of surgery and at 8 and 14 h the following 2 days. It was carried out by the patient who was asked to score his/her dizziness on a VAS scale as described above. Blood pressure (systolic and diastolic) was measured in the supine and upright standing position with the measurement commencing within 60 s after standing up. Mean arterial blood pressure (MAP) was used in the data analyses. The definition of orthostatic function was: being able to walk 5 m at 6, 10, 24 and 48 h post-operatively.

Discharge criteria from the PACU to the ward was assessed every 15 min until obtained and carried out by a nurse unaware of which treatment the patient had received. We used the following discharge criteria from the PACU: (1)

sufficient level of consciousness (aroused by verbal stimuli); (2) able to maintain a free airway; (3) adequate breathing with $SaO_2 \geq 95\%$ when administering a max of 5 l O_2/min; (4) only mild or no PONV (< 30 mm); and (5) adequate pain control (i.e. VAS no more than 30 mm at rest).

The definition of LOS was the time from the end of surgery until the patient met the discharge criteria from the ward: (1) able to get in and out of bed; (2) able to get dressed; (3) able to sit down in a chair and get up again; (4) able to walk 50 meters with or without walking aids (crutches etc); (5) able to flex the knee to ≥ 70°; (6) able to walk stairs; (7) pain manageable with oral analgesics; and (8) acceptance to be discharged. These actions were performed by the patients without assistance.

Discharge criteria were checked at 8 h and again 14 h and carried out by a nurse blinded to which treatment the patient had received. The actual time at which the patient was discharged from the ward was noted and compared with LOS.

Nausea was monitored using a VAS scale as described above. The frequency of vomiting was registered. PONV was monitored at 8 h and again at 14 h during the study.

Blood loss during surgery was calculated by weighing the gauze and draping sheets. Twenty-four hours after the end of surgery, a venous blood sample was taken and the haemoglobin concentration was compared with the pre-operative value.

Six months post-operatively, the patients were interviewed via telephone. They were asked to rate the anaesthesia they had received on a 100-mm scale where 0 = worst imaginable experience and 100 = best possible experience. During the same interview, they were asked if they would like to change the type of anaesthesia they would like to have in the event of a subsequent THA having the possibility to choose between the two types of anaesthesia used in this study.

Surgery

Surgery was performed with the patient in the lateral position. A posterior approach was used in all procedures. The piriformis tendon was released and resutured together with the incised posterior capsule. The quadratus femoris muscle was left intact. Both uncemented and cemented total hip implants were used and implanted according to the manuals supplied by the manufacturers.

Statistical analyses

Power and sample size calculation was carried out (with http://biostat.mc.vanderbilt.edu/twiki/bin/view/Main/PowerSampleSize).

We planned a study of a continuous response variable from independent control and experimental subjects with one control(s) per experimental subject. In a previous pilot study, the response within each subject group was 72 h with standard deviation (SD) of 42. If the true difference between experimental and control means was 17 h, we would need to study 60 experimental subjects and 60 control subjects to be able to reject the null hypothesis that the population means of the experimental and control groups are equal with probability (power) 0.8. The Type I error probability associated with the test of this null hypothesis is 0.05. To compensate for drop-outs, we decided to include 124 patients.

Data analyses were performed using SPSS version 20.0 (SPSS, Chicago, IL, USA). Data distribution was tested for normality with Sharpio–Wilks test and residual plots. According to data distribution, either Mann–Whitney *U*-test for unpaired data or Student *t*-test was used. For binary data, we used chi-square test. Data are presented as mean (± SD) or median [25–75% interquartile range (IQR)]. A P-value < 0.05 was assigned statistical significance.

Results

Recruitment started January 2013 and ended in May 2013. A total of 124 consecutive patients were assessed for eligibility by four orthopaedic surgeons and 120 patients were included following the pre-operative visit by the anaesthetist [Fig. 1. (CONSORT flow diagram)]. Two patients in the SA group were excluded because of the conversion to GA. Subject characteristics and surgical data are presented in Table 1.

The median (IQR) time to fulfilling the discharge criteria from the PACU was 0 min (0) in the SA group and 90 min (50–125) in the GA group (P = 0.004). The median (IQR) LOS (fulfill-

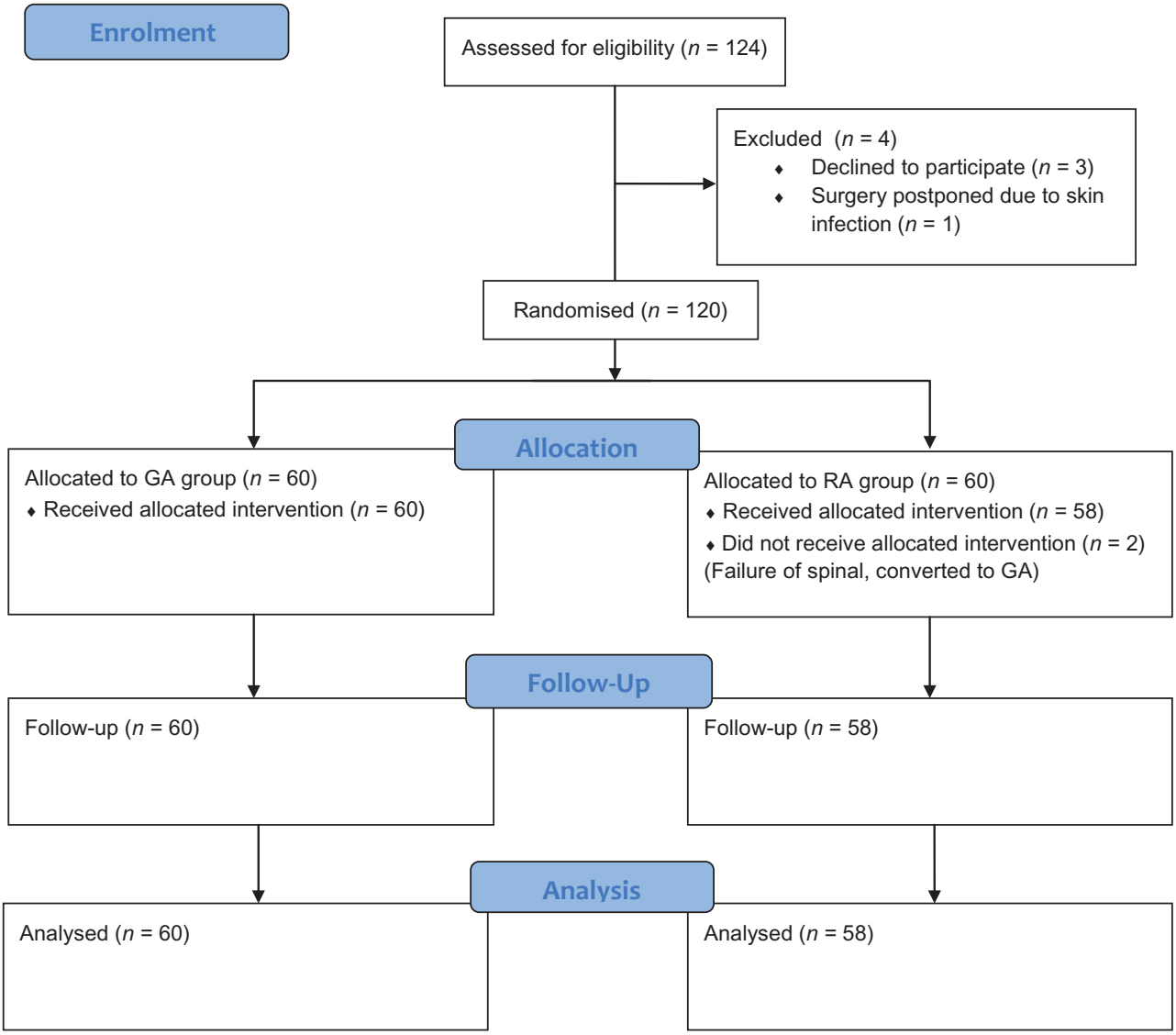

Fig. 1. CONSORT flow diagram for the study.

ing discharge criteria from the ward) was shorter in the GA group 26 h (23–30) compared with the SA group 30 h (25–45) ($P = 0.004$) but without difference between groups on the actual day of discharge (2 vs. 2 days) (χ^2-test; Table 2). When the patients were not discharged in spite of meeting the discharge criteria, this was due to factors such as organisational (22 patients) and general fatigue (6).

There were no differences in pre-operative pain scores between the groups. Patients in the GA group had higher pain scores during the first four post-operative hours, but this changed from 6 h onward as the SA patients had higher pain scores both a rest and during the three other movements (Fig. 2).

During the first 24 post-operative hours, the median (IQR) consumption of morphine was 27 mg (13–40) in the GA group and 27 mg (10–45) in the SA group (*n.s.*). The median number (IQR) of administered PCA doses was 15 (10–26) in the GA group and 18 (8–26) in the SA group (*n.s.*). The median (IQR) number of requested, but not administered, PCA doses was 24 (5–91) in the GA group and 15 (10–38) in the SA group (*n.s.*). The distribution of the median (IQR) number of requested and administered PCA doses during

Table 1 Demographics and surgical data.

	GA group $n = 60$	SA group $n = 58$
Weight (kg)	84 ± 11	83 ± 14
Height (cm)	172 ± 9	171 ± 8
Male/female	32/28	27/31
Age (years)	68 ± 9	66 ± 78
ASA physical status		
I	17	15
II	34	35
III	9	8
Duration of surgery (min)	72 ± 17	73 ± 20
Intra-operative bleeding (ml)	285 (201–487)	317 (195–410)

Weight, height age and duration of surgery presented as mean ± standard deviation. Intra-operative bleeding presented as median (interquartile range). Gender and ASA status presented as numbers. No statistically significant differences in duration of surgery or intra-operative bleeding between the groups. ASA, American Society of Anesthesiologists; GA, general anaesthesia; SA, spinal anaesthesia.

Table 2 Discharge from the ward according to criteria actual discharge.

	GA group $n = 60$	SA group $n = 58$	P	GA group $n = 60$	SA group $n = 58$	P
POD1, 8 h	6	4	*n.s.*	5	2	*n.s.*
POD1, 14 h	42	29	< 0.05	22	20	*n.s.*
POD2, 08 h	54	45	*n.s.*	32	26	*n.s.*
POD2, 14 h	59	53	*n.s.*	55	54	*n.s.*
After POD2	–	–	–	60	58	*n.s.*

Cumulative number of patients meeting the discharge criteria from the ward at different post-operative times and the actual number of patients that in fact were discharged (chi-square test, GA group vs. SA group). POD1 is the first day after surgery. GA, general anaesthesia; SA, spinal anaesthesia.

the first 24 h after the operation are shown in Fig. 3.

The median (IQR) intra-operative blood loss was 317 ml (195–410) in the SA group and 285 ml (201–487) in the GA group (*n.s.*). The mean (SD) haemoglobin concentration 24 h after the surgery was 117 ± 14 g/l in the SA group and 118 ± 15 g/l in the GA group (*n.s.*). No blood transfusions were given to any of the patients during the study. The mean (SD) drop in haemoglobin concentration was 20 ± 9 g/l in the SA group and 22 ± 8 g/l in the GA group (*n.s.*). In the SA group and GA group, 35 and 38 patients, respectively, did not require any bladder catheterisation, whereas 23 patients in the SA group and 22 in the GA group had at least one intermittent catheterisation (*n.s.*).

Patients in the GA group had lower dizziness scores ($P < 0.001$) (Fig. 4). Orthostatic function was more affected in the SA group (χ^2-test) as 26 subjects in the SA group vs. 56 in the GA group were able to walk 5 m after 6 h ($P = 0.008$). After 10 and 24 h the same numbers were 60 and 60 in the GA group and 55 and 57 in the SA group, respectively (*n.s.*). There were no falls in either group. The patients in the SA group who were unable to walk at 6 h reported muscular weakness as the cause. No significant differences in MAP were found between the groups at any time. Nausea scores were higher in the SA group ($P = 0.043$), but there was no difference in the number of subjects that vomited (Table 3).

The anaesthesia satisfaction score was not different between the groups. However, fewer subjects in the GA group indicated that they would like to change the method of anaesthesia for a subsequent operation compared with the SA group (5 vs. 13, χ^2-test, $P = 0.022$).

No deaths were recorded at the 6-month follow-up, time but two patients developed atrial fibrillation in the early post-operative phase, one in each group.

Discussion

THA is the only successful intervention in treating the morbidity of end-stage hip osteoarthritis and thus is a very common surgical procedure with more than 250,000 performed annually in US alone.[11] This accounts for a considerable portion of the health care budget and it is a major future challenge to be able to perform such a large number of operations without affecting medical quality or increasing the waiting period.

In this study, patients receiving GA had slightly shorter LOS (time to reach discharge criteria), less dizziness and nausea, and slightly better orthostatic function compared with SA. Pain scores were also lower after 6 h without an increase in opioid consumption. However, patients in the SA group were ready to be discharged from the PACU earlier compared with the GA group. No difference was found in blood loss, actual or change in

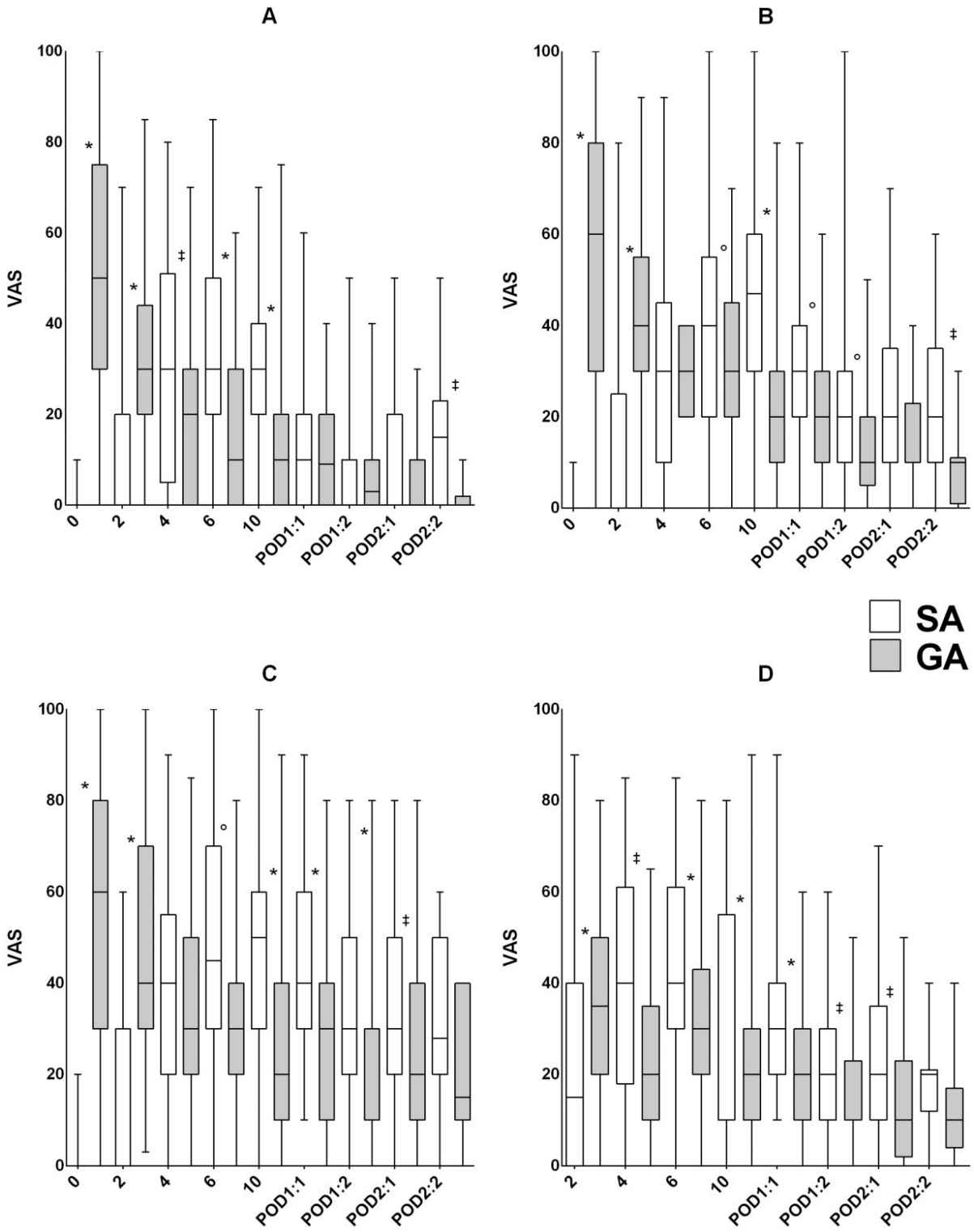

Fig. 2. Pain (visual analogue scale, VAS 0–100 mm) at (A) rest, (B) during knee flexion, (C) with the knee straight and hip flexion and (D) when walking. Filled bars = general anaesthesia (GA) and non-filled bars = spinal anaesthesia (SA). Line within the boxes indicate median and the boxes indicate 25–75% interquartile range (IQR). Whiskers indicate range. *$P < 0.001$, °$P < 0.01$ and ‡$P < 0.05$. Numbers indicate the hours after surgery. POD 1 : 1 and 1 : 2 is the day after surgery at 8 and 14 h. POD 2 : 1 and 2 : 2 represent the equivalent times the second post-operative day.

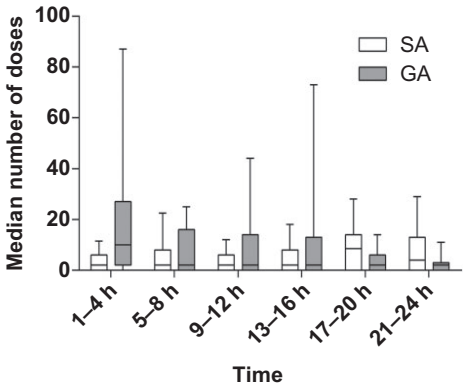

Fig. 3. Median number of requested patient-controlled analgesia (PCA) doses during the first 24 h after surgery. Line within the boxes indicate median and boxes indicate 25–75% interquartile range (IQR). Whiskers indicate 90th percentiles. $P = 0.0009$ at 1–4 h and 21–24 h. $P < 0.008$ at 17–20 h. GA, general anaesthesia; SA, spinal anaesthesia.

post-operative haemoglobin concentration or the need for urinary catheterisation between the SA and GA groups.

On the first post-operative day, 60% of the patients met or had met the discharge criteria from the ward, as reported previously.[12] However, the GA patients fulfilled discharge criteria slightly earlier than the SA patients (26 vs. 30 h), possibly due to reduced pain after 4 h, nausea and dizziness. The actual discharge was similar (2 days) in both groups. The main reasons for not being discharged in spite of meeting discharge criteria were organizational causes and general fatigue. Patients in the SA group met the discharge criteria from the PACU earlier compared with the GA patients. The cause of this difference was that GA patients had higher pain scores in the early post-operative phase and hence did not fulfil the discharge criteria from the PACU.

In a previous study, we showed that GA resulted in slightly earlier recovery, less post-operative pain and consumption of opioids, dizziness and nausea and with earlier ability to walk compared with SA for patients undergoing fast-track to total knee arthroplasty.[3] The present study is in many methodological aspects identical with that study. However, when studying total knee arthroplasty, we used the high-volume local infiltration technique in the knee and the surrounding tissues as described in 2008.[13] In this study local infiltration technique was not used because it has previously been shown that this may not reduce pain after THA[14] when the surgery is performed using intrathecal isobaric bupivacaine with multimodal opioid-sparing analgesia.

In contrast to older studies, we chose to use TCI as the GA method as it produces rapid emergence from anaesthesia.[3,15] Despite recommendations, we did not use intrathecal morphine in the SA group,[16] and this may have influenced our results. However, intrathecal morphine produces a limited analgesic effect and has undesirable side effects especially for elderly.[17] Moreover, we used a comprehensive multimodal non-opioid analgesic regime, which was intended to reduce the need for intrathecal morphine. Oxycodone was administered to the patients in the GA group at the end of surgery. This was carried out because of the short-lived analgesic effects of remifentanil used in the TCI technique. At the same time, we found it less appropriate to administer intra-operative oxycodone in the SA group, receiving intrathecal local anaesthetics. Nevertheless, the lack of oxycodone administration in the SA group might have influenced our results.

In this study, the patients in the GA group had less dizziness compared with those in the SA group. Because dizziness and muscle weakness can delay discharge,[12] it is important to reduce these symptoms and this might be feasible by exchanging SA with GA calling for further studies. Orthostatic hypotension may not explain the increase in dizziness in the SA group[18] because we found no differences in MAP between the groups. However, we did not imply a detailed study of hemodynamic function to evaluate orthostatic tolerance as demonstrated earlier.

SA may contribute to urinary bladder dysfunction, but 62% of the patients were managed without any bladder catheterisation. This has been reported earlier,[3] and providing that urinary bladder scans are performed regularly, it is an improvement to avoid urinary catheters because of potential complications such as urinary tract infections and subsequent risk of deep wound infections.[19,20]

There was no difference between the groups in intra-operative bleeding, as suggested earlier.[21,22] Furthermore, blood loss was quite limited (about 300 ml) in our study, probably due to extensive surgical experience and the fairly short durations of surgery.

In a review by Macfarlane et al., they found that there was insufficient evidence in the

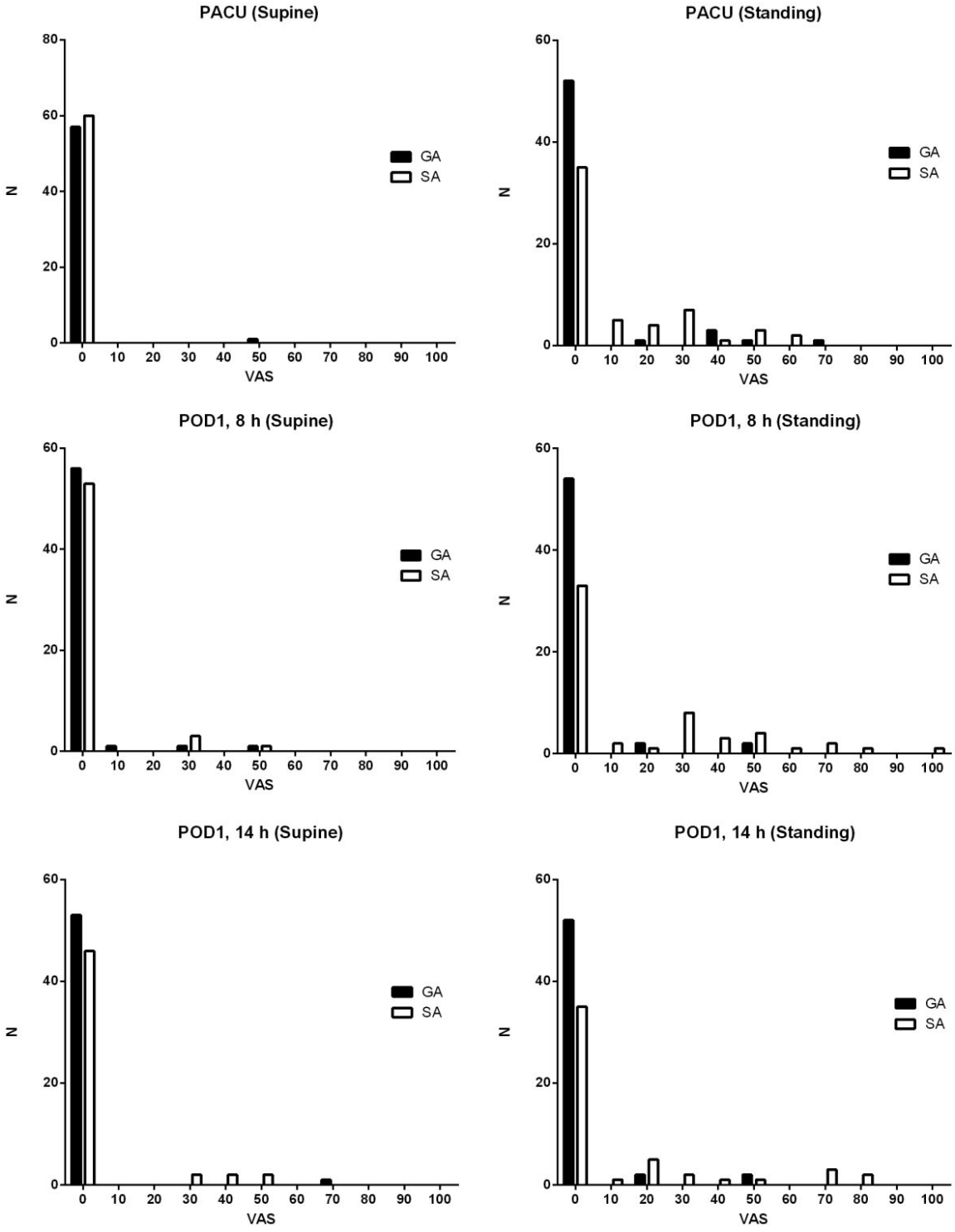

Fig. 4. Number of subjects having different 'dizziness-scores' (visual analogue scale, VAS 0–100 mm) when in a supine or standing up position. Measurements made before discharge from the post-operative care unit (PACU) and the day after surgery (POD1) at 8 and 14 h. Total 'mass' of dizziness compiled as area under the curve of the given VAS scores, analysed by Mann–Whitney test to compare the general anaesthesia (GA) patients with the spinal anaesthesia (SA) patients. Statistically significant differences (more subjects having higher scores in SA group) in standing position ($P < 0.001$).

Table 3 Post-operative nausea and vomiting.

	GA group $n = 60$	SA group $n = 60$	P	GA group $n = 60$	SA group $n = 60$	P
PACU	0 (0) [0–10]	0 (0) [0–85]	0.011	–	–	–
POD1, 8 h	0 (0) [0–60]	0 (0) [0–90]	0.043	–	–	–
POD1, 14 h	0 (0) [0–40]	0 (0) [0–60]	0.034	1	5	*n.s.*
POD2, 8 h	0 (0) [0–10]	0 (0) [0–60]	*n.s.*	–	–	–
POD2, 14 h	0 (0) [0]	0 (0) [0–40]	*n.s.*	0	0	*n.s.*

Median (interquartile range) [range] score for post-operative nausea (Mann–Whitney). Number of patients vomiting each day (chi-square test). POD1 is the first day after surgery. GA, general anaesthesia; PACU, post-operative care unit; SA, spinal anaesthesia.

literature to conclude that anaesthetic technique influences mortality, cardiovascular morbidity or the incidence of thrombo-embolic complications among patients undergoing THA,[22] but that regional anaesthesia could reduce blood loss, pain and nausea. However, their review was based on studies carried out between 1990 and 2008, a time when neither the fast-track methodology nor TCI were well-established techniques for THA patients.

There are several limitations of this study. One is that we did not study serious adverse events or mortality. In order to do this in a prospective randomised trial, we would require a significantly larger study population.[23] Although major complications after regional anaesthesia are rare,[24] a recent study showed that neuraxial blocks are associated with an increased risk of serious morbidity among patients with cardiovascular diseases.[25] The patients in our study were not exceptionally at high cardiovascular risk, and hence, one would not expect any differences between the two groups. Furthermore, Pitkänen et al. analysed 216 closed claims during 2000–2009 for central neuraxial blocks and found a 1.9 : 100,000 risk for permanent complications.[26]

In a large systematic review, thrombo-embolic and pulmonary complications were reported to be less frequent when using regional anaesthesia.[2] However, this review evaluated studies that were performed 15–30 years ago. In another study, it was shown that perioperative stroke was more common after general than regional anaesthesia.[27] Today, fast-track surgery has enhanced recovery and reduced morbidity leading to better outcome.[28] Furthermore, in a recent study of 400,000 patients undergoing total hip or total knee arthroplasty, major morbidity and mortality were lower in those receiving regional anaesthesia compared with GA.[29] However, this study was observational and, as such, treatment assignment was non-random and therefore with a risk that the results may reflect differences in patient morbidity instead of effects caused by type of anaesthesia. The same applies to other recent database studies where neuraxial anaesthesia was followed by reduced mortality, risk of pneumonia, surgical site and systemic infections and a decreased odds for combined major complications.[30–33]

Another limitation of our study is that the investigating physicians and OR staff were aware of which anaesthetic technique was being used. However, all caregivers involved in the evaluation and assessment of the patients post-operatively were otherwise unaware of treatment allocation.

In summary, our results in fast-track THA shows that GA resulted in a more favourable recovery profile compared with SA, calling for large-scale prospective comparative studies.

Acknowledgements

We thank the orthopaedic surgeons and staff at the Department of Anaesthesiology and the Department of Orthopedic Surgery, Hässleholm Hospital, Sweden, for help and assistance.

Authors' contributions

A. H.: Did pre-operative evaluation, enrolled patients, administered anaesthesia, participated in the design of the study, performed statistical analyses and wrote the manuscript.

H. K., P. L. and S. T.-L.: Coordinated and designed the study and contributed in writing the manuscript.

A. H. and S. T.-L.: Reviewed the data, performed data analysis and attest to the integrity of the original data reported in this manuscript.

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