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Clinical Investigation

CLINICAL INVESTIGATION

SmartPilot® view-guided anaesthesia improves postoperative outcomes in hip fracture surgery: a randomized blinded controlled study

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Abstract

Background. Both under-dosage and over-dosage of general anaesthetics can harm frail patients. We hypothesised that computer-assisted anaesthesia using pharmacokinetic/pharmacodynamic models guided by SmartPilot® View (SPV) software could optimise depth of anaesthesia and improve outcomes in patients undergoing hip fracture surgery.
Methods. This prospective, randomized, single-centre, blinded trial included patients undergoing hip fracture surgery under general anaesthesia. In the intervention group, anaesthesia was guided using SPV with predefined targets. In the control group, anaesthesia was delivered by usual practice using the same agents (propofol, sufentanil and desflurane). The primary endpoint was the time spent in the "appropriate anaesthesia zone" defined as bispectral index (BIS) (blinded to the anaesthetist during surgery) of 45–60 and systolic arterial pressure of 80–140 mm Hg. Postoperative complications were recorded for one month in a blinded manner.
Results. Of 100 subjects randomised, 97 were analysed (n=47 in SPV and 50 in control group). Anaesthetic drug consumption was reduced in the SPV group (for propofol and desflurane). Intraoperative duration of low BIS (<45) was similar, but cumulative time of low systolic arterial pressure (<80 mm Hg) was significantly shorter in the SPV group (median (Q1-Q3); 3 (0–40) *vs* 5 (0–116) min, P=0.013). SPV subjects experienced fewer moderate or major postoperative complications at 30-days (8 (17)% *vs* 18 (36)%, P=0.035) and shorter length of hospitalisation (8 (2–20) *vs* 8 (2–60) days, P=0.017).
Conclusions. SmartPilot® View-guided anaesthesia reduces intraoperative hypotension duration, occurrence of postoperative complications and length of stay in hip fracture surgery patients.
Clinical trial registration. NCT 02556658.

Key words: anaesthesia, general; hip fractures; length of stay; monitoring, intraoperative; postoperative complications

Optimal depth of anaesthesia is a main determinant of the quality of postoperative recovery and outcome after general anaesthesia. Insufficient anaesthesia exposes patients to intraoperative awareness, with potential long-term psychological consequences,[1] while excessively deep anaesthesia induces hypotension, which is independently associated with increased postoperative morbidity[2] and mortality.[3–5] Consequently, accurately determining anaesthesia levels is of crucial importance. Unfortunately, to date we only have electroencephalogram-derived indices to "monitor" anaesthesia levels, but they seem

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Editor's key points

- Computer-assisted drug dosing using pharmacokinetic/pharmacodynamic models might help optimise depth of anaesthesia and improve postoperative outcomes.
- A single centre prospective study compared computer-assisted dosing of hypnotic and opioid drugs with usual care in 97 hip fracture surgery patients undergoing general anaesthesia.
- Computer-assisted delivery of propofol, desflurane and sufentanil reduced intraoperative hypotension, postoperative complications and length of hospital stay.

insufficiently reliable to optimise anaesthesia.[6 7] More predictive tools are needed to guide physicians in the administration of anaesthetic drugs.

In this context, recent monitors based on pharmacological models, such as SmartPilot® View (SPV) software (Dräger Medical, Lübeck, Germany), appear promising.[8] SPV predicts anaesthesia levels for the next 10 min and combines the effects of hypnotic and analgesic drugs. However, clinical validation of this tool remains limited. Two prospective non-randomized studies found that SPV-guided anaesthesia reduces anaesthetic consumption, but they did not show significant effects on either intraoperative haemodynamics or postoperative outcomes.[9 10] Both studies involved patients with an ASA physical score of I or II, mostly aged less than 65 yr. We assumed that SPV would be more relevant for frailer patients, such as those undergoing hip fracture surgery.[11] Indeed, target controlled anaesthesia management has already been demonstrated to be safer in such patients.[12] We hypothesized that the quality of SPV-guided general anaesthesia would be superior to usual practice. To test this, we conducted a prospective, randomized, blinded, controlled trial to evaluate the quality of SPV-guided general anaesthesia compared with usual practice, in patients undergoing hip fracture surgery. We quantified time spent in an "optimal anaesthesia zone" and compared postoperative outcomes (complications and length of stay) using SPV-guided anaesthesia or usual care.

Methods

Study design

This randomized, controlled, blinded single-centre trial (*NAPfem*, registered on www.clinicaltrial.gov as NCT02556658) was conducted at the University Hospital of Angers, France, between February 2015 and June 2016. The local Ethics Committee (Comité de Protection des Personnes Ouest II – Angers) approved the study (ref.: 2014/27). All subjects provided written informed consent.

Consecutive patients undergoing hip fracture surgery were screened for eligibility criteria (adult patients $\leq$ 90 yr old, body weight (BW) 40 – 140 kg, height 150 – 200 cm, ability to answer a questionnaire, ASA physical status I-III, and scheduled surgery under general anaesthesia alone). Exclusion criteria were cognitive impairment, alcoholism, pregnancy, ASA physical status IV or V, or contraindication to general anaesthesia. Eligible patients who consented to participate were randomly assigned to SPV-guided anaesthesia (SPV group, see below for details) or usual practice (control group). Only the anaesthetist in charge during the intraoperative period knew group assignment. Research technicians and all staff (doctors, surgeons, nurses, etc.) in the medical ward were blinded to group assignment. Anaesthetists who work in the emergency operating room do not take care of the patients in the ward.

SmartPilot® view

The SmartPilot® View (SPV) medical device uses population-based pharmacokinetic and pharmacodynamic (PK/PD) models to evaluate and predict anaesthesia levels according to the noxious stimulation response index (NSRI).[13] SPV displays current anaesthesia level and the expected course of anaesthesia over the next 10 min, taking into account hypnotic-opioid interactions. Current and predicted anaesthesia levels are depicted as dots superimposed on NSRI isoboles (Supplementary Fig. S1).

SPV (software version 3.00.12) was connected to the anaesthesia ventilator (Perseus®, Dräger Medical, Lübeck, Germany) so that ventilation and volatile anaesthetic settings were automatically integrated. Data relating to subject characteristics and propofol and sufentanil bolus injections were entered manually into the SPV monitor. Doses and modification of ventilator settings were decided according to SPV values observed and predicted in the SPV group. In the control group, the SPV monitor was not used.

Anaesthesia management

Angiotensin II antagonists, angiotensin-converting enzyme inhibitors and oral anticoagulants were discontinued after diagnosis of hip fracture, according to institutional protocol. No premedication was administered before surgery.

In both groups, the only allowed drugs were propofol, sufentanil and atracurium for anaesthesia induction, and desflurane and sufentanil for anaesthesia maintenance. Desflurane was stopped at the end of surgical closure. In the SPV group, sufentanil, propofol and desflurane doses were determined to achieve predefined NRSI isoboles. In short, the dark grey isobole was targeted for intubation and surgical incision, the mild-grey isobole for the rest of surgery and the light-grey isobole for surgical closure (Supplementary Fig. S1). In the control group, the anaesthetist in charge administered these drugs in accordance with usual practice. In both groups, hypotension (systolic arterial pressure (SAP)$<$80 mm Hg or higher if clinically indicated) was treated actively, either using ephedrine, fluids and/or lowering depth of anaesthesia.

In addition to standard monitoring, bp was recorded at 20-s intervals using the non-invasive ClearSight™ (Edwards Lifesciences, Irvine, CA) system. Anaesthesia depth was recorded using bispectral index (BIS) monitoring (BISx Power Link™, Aspect Medical Systems, Newton, MA, USA) in both groups, but the monitor remained hidden to physicians. BIS data were recorded at one s intervals. All data from ClearSight™ and BIS were stored in a computer for analysis by the statistician, blinded to the group assignment.

Statistical analysis

The primary outcome was percentage of time spent in the "*optimal anaesthesia zone*" (OAZ), defined as SAP between 80 and 160 mm Hg and BIS between 45 and 60, as defined by Monk and colleagues.[14] Total anaesthesia duration was defined as the time from the beginning of i.v. induction to discontinuation of desflurane.