ORIGINAL ARTICLE

Caudal block with analgosedation – a superior anaesthesia technique for lower abdominal surgery in paediatric population

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ABSTRACT

Aim To compare intraoperative hemodynamic and respiratory stability and postoperative emergence delirium between two anaesthesia regimens in children (caudal block with intravenous continuous analgosedation versus general endotracheal anaesthesia) and intensity of postoperative pain and quality of postoperative analgesia.

Method Forty children aged 2-6 years who underwent lower abdominal surgery were randomized depending on performed anaesthesia into two groups: caudal block with analgosedation (group CB) and general endotracheal anaesthesia (group GA). Intraoperative hemodynamic and respiratory stability were evaluated measuring systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MAP), heart rate (HR) and arterial oxygen saturation (SaO_2) in preinduction (t_0), at the moment of surgical incision (t_1), 10 minutes after surgical incision (t_2) and at the time of skin suturing (t_3). Postoperative emergence delirium was evaluated using Paediatric Anaesthesia Emergence Delirium score (PAED). Postoperative pain was evaluated by Children's and Infants' Postoperative Pain score (CHIPPS). Both scores were recorded every 5 minutes during first half hour postoperatively, additionally after 60 minutes postoperatively for CHIPPS score.

Results SBP, DBP and MAP were lower at t_1 ($p<0.0001$), t_2 ($p<0.05$) and t_3 ($p<0.001$) in the group CB. HR was lower at all studied time points ($p<0.005$) in the group CB. SaO_2 was lower in the CB group but comparable with the GA group. PAED and CHIPPS scores were lower at 5, 10, 15, 20 and 25 minutes postoperatively ($p<0.001$) in the CB group.

Conclusion Caudal block with analgosedation provides better control of intraoperative hemodynamic conditions, postoperative emergence delirium and postoperative pain than general endotracheal anaesthesia.

Key words: analgesia, children, hemodynamic, emergence delirium, postoperative pain

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INTRODUCTION

General endotracheal anaesthesia could expose children to various perioperative hemodynamic (53.3%) and respiratory (46.7%) complications or metabolic changes with potentially neurotoxic effects (1,2). The risk of perioperative complications is higher in children with congenital cardiac abnormalities, in infants born preterm and children with acute respiratory infections. The combination of general anaesthesia and regional anaesthesia technique reduces neurohumoral response to surgery, alleviates intraoperative inhalation and consumption of opioid agents, accelerates early mobilisation and recovery (3). Caudal block is achieved by application of local anaesthetic in epidural space through sacral hiatus in caudal canal (4). Although the first application of caudal block was described in 1933, caudal anaesthesia did not gain a degree of popularity until the early 1960 (5). A single shot caudal block as additional technique to general anaesthesia is commonly used for postoperative pain relief in paediatric urologic, lower abdominal and lower limbs surgery (6). Certain advantages of caudal anaesthesia in relation to general endotracheal anaesthesia are avoidance of endotracheal intubation and the use of muscle relaxant, reduction of the incidence of respiratory depression and postoperative apnoea, absence of postoperative nausea and vomiting, simplicity of performing and low cost of service (7). Caudal block as a sole anaesthesia technique for subsequent surgery in infants and children seems as a good and safe alternative to general anaesthesia. But caudal anaesthesia in awake infants and children is associated with children's crying and moving during the caudal puncture, which can lead to potential injuries or unsuccessful caudal block.

The combination of caudal block with continuous intravenous analgosedation can be used as an independent anaesthesia procedure to provide good conditions for patients' status as well as operation in general (8). This regimen considers performing caudal epidural block as a regional block technique simultaneously applying continuous intravenous analgosedation with propofol and ketamine (9). Caudal block with analgosedation used as a sole anaesthesia allows subsequent surgery in sedated and spontaneously breathing infants and children. The procedure can be used for surgical operations below umbilicus such as retention of testicles, torsion of testicles, phimosis, inguinal hernia, appendectomy, hypospadia and circumcision (10). Caudal block with analgosedation versus general endotracheal anaesthesia was not studied much previously.

Aim of this study was to compare caudal block with propofol and ketamin intravenous analgosedation and general endotracheal anaesthesia in terms of intraoperative hemodynamic and respiratory conditions and intensity of postoperative emergence delirium (ED) in children. Additionally, a difference between intensity of postoperative pain and quality of postoperative analgesia depending on two anaesthesia protocols were evaluated.

PATIENTS AND METHODS

Patients and study design

This prospective randomized, double-blinded study was conducted at the Department of Anaesthesiology and Intensive Care Unit of the Cantonal Hospital in Zenica, Bosnia and Herzegovina. The study took place during three months, from February to May 2017.

Forty children were included in the study. Inclusion criteria were: children aged 2-6 years undergoing elective lower abdominal surgery in the supine position and American Society of Anaesthesiologists (ASA) physical status class I–II (11). Exclusion criteria were: emergence surgery, hypovolemia, electrolyte disturbance, shock, puncture site or interspinal area infection, deformation of spine, dermoid cysts and history of allergy to any of the study drugs. A day before elective surgery children were examined by an anaesthesiologist. Evaluation of general status, medical documentation and ASA classification was conducted. Children who fulfilled eligibility criteria were randomly divided into two equal groups of 20 patients each: the CB (caudal block) study group in which caudal anaesthesia with analgosedation was performed and the GA (general anesthesia) control group in which conventional general endotracheal anaesthesia was performed. Patients were randomized by a nurse who was not involved in the study. Randomization was performed by computer generated random number sequence and placed in opaque sealed envelopes until the child was anesthetized.

An approval of the Ethics Committee of the Cantonal Hospital Zenica was obtained. Children's parents signed written informed consents.

Methods

Anaesthesia protocol. All children were kept fasting for 6 hours and were premedicated using midazolam 0.4 mg /kg orally, 30 minutes prior to anaesthesia induction. In the operating room, an intravenous cannula of 22G or 24G was sited to the dorsa of patients' hand. Before performing caudal anaesthesia, children were monitored with non-invasive arterial blood pressure, electrocardiography and pulse oximetry. A bolus dose of propofol 1-1.5 mg/kg was administered intravenously for anaesthesia induction, which was followed with continuous infusion of propofol 10 mg/kg/h. A bolus dose of ketamine 1 mg/kg was administered before the puncture of caudal block and before surgical incision. Caudal anaesthesia was performed in aseptic conditions, with the patients in left lateral position with legs at 90 over the hips and 45 over the knees. Intravascular or subarachnoid placement were ruled out by maintaining the needle open for 10-15 seconds and gently aspirating the syringe. After recording negative aspiration 0.25% ropivacaine 1ml/kg was injected into epidural space. During surgical procedure, children were breathing spontaneously, lightly sedated. The positioning of the head was adapted for the preservation of the free airway. Desaturation was defined as a fall of the pulse oximetry to 95% SaO_2 and oxygen was provided by facial mask at flow rates of 4 l/min. If sedation was inadequate supplemental doses of propofol 0.5 mg/kg were administered. Sedation was considered as adequate, when the patient was unconscious and arousable only with significant physical stimulation. Surgery was initiated 10 minutes after performing the caudal block. The caudal block was considered as unsuccessful block if the patient moved limbs, had an increased heart rate, or mean arterial pressure more than 15% compared with values obtained just before the surgical skin incision. In such instances, the patient was to be withdrawn from the study. During the surgery, propofol infusion was reduced to 5 mg/kg/h. At the time of skin suturing, propofol was stopped. The patients were transported still asleep to the postoperative recovery room.

In the GA group, patients were preoxygenated by facial mask for 3 minutes. Anaesthesia was induced by propofol 3 mg/kg, fentanyl 1 μgr/kg and vecuronium bromide 0.1 mg/kg. Endotracheal intubation was performed 120 seconds later. Balanced anaesthesia was maintained using sevoflurane minimum alveolar concentration 0.5-1 ‰, N_2O 50% in oxygen, at a total flow of 2 L/min. End tidal carbon dioxide was maintained at 30-35 mmHg. Mechanical ventilation was done with a tidal volume of 8-10 mL/kg and the rate of 20-25 respirations per minute. At the time of skin suturing, paracetamol 15 mg/kg was given intravenously. At the end of the surgery, patients were extubated fully awake and transferred to the postoperative recovery room. Continuous monitoring of vital parameters was used in both groups, in addition of capnography in the GA group. One experienced anaesthesiologist performed caudal block in all children and another experienced anaesthesiologist performed all general endotracheal anaesthesia. They were blinded to the study protocol.

Evaluation of intraoperative hemodynamic and respiratory conditions. Systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial blood pressure (MBP), heart rate (HR) and arterial oxygen saturation (SpO_2) were measured at four study time points. The basal value (t_0) was taken in preinduction, just before administration of propofol, t_1 – at the moment of the surgical incision, t_2 – 10 minutes after the surgical incision and t_3 – at the time of skin suturing. Hypotension and bradycardia or hypertension and tachycardia were defined as a 20% decrease or increase in SBP and HR from baseline and episodes of each of them were recorded.

Evaluation of postoperative emergence delirium. Postoperative emergence delirium (ED) was defined as a disorder that occurred during awakening from anaesthesia in the immediate postoperative period and was evaluated using Paediatric Anaesthesia Emergence Delirium score (PAED) (12). The scale consists five parameters: eye contact, purposeful actions, awareness of surroundings, child is restless and child is inconsolable. Three first items of the PAED scale range from 0 (extremely) to 4 (not at all). Two last items of the PAED scale are scored from 0 (not at all) to 4 (extremely). ED was recorded every 5 minutes in the first half hour postoperatively. Children with a total PAED score of 10 or higher were considered as agitated and received a rescue medication of propofol 1 mg/kg intravenously.

Evaluation of postoperative pain intensity and quality of postoperative analgesia. Intensity of postoperative pain was evaluated using Children's and Infants' Postoperative Pain score (CHIPPS), which includes five items: crying, facial expression, posture of the trunk, posture of the legs and motor restlessness (13). Each item ranked from 0 to 2 points. The CHIPPS score was estimated every 5 minutes in the first half hour postoperatively and repeated at 60 minutes after surgery. The total CHIPPS score ≥4 indicated an administration of paracetamol 15 mg/kg intravenously. The quality of postoperative analgesia was assessed by recording the time of first and second analgesic request and the number of analgesic doses in each group in 24 hours postoperatively.

Statistical analysis

Sample size was estimated using sample size calculator software with 95% confidence interval and power of 80%. Statistical significance was considered as $p<0.05$. Categorical variables were analysed by Pearson's $\chi2$ test or Fisher's exact test and presented as frequency and relative number of cases (percentage). The parametric variables were expressed as mean and standard deviation and analysed by Student's t-test or Levene's Test for Equality of Variances as appropriate.

RESULTS

Data were obtained from 40 consecutive children undergoing subumbilical surgery. None of the children required additional sedation in the caudal anaesthesia group and there was no unsuccessful caudal block during the study. No children were excluded from the study (Figure 1). There was no statistically significant difference of demographic parameters between the groups except ASA physical status grade. In the CB group nine (45%) children were ASA grade I and 11 (55%) children were ASA grade II versus 16 (80%) children ASA grade I and four (20%) children ASA grade II in the GA group (p <0.024) (Table 1).

Hemodynamic parameters differed from the basal value within each group. Significant decrease of the mean SBP was noted at the moment of the surgical incision (10.1%) in the CB group (p<0.05). In the GA group, the mean SBP increased at the moment of the surgical incision (7.25%) and decreased 10 minutes after the surgical incision (12.67%; p<0.05). The mean DBP showed significant decrease at the moment of the surgical incision (15.01%) and 10 minutes after the surgical incision (12.01%) in the CB group (p<0.05). Contrary, in the GA group, mean DBP increased at the moment of the surgical incision (4.48%), and then showed a decrease 10 minutes after the surgical incision (14.21%; p<0.05). The mean value of the HR remained stable during the study in the CB group. In the GA group, the mean value of HR decreased at the moment of the surgical incision (12.39%) and at the time of skin suturing (6.7%; p<0.05). Comparison of hemodynamic parameters between the groups presented better hemodynamic conditions in the CB group (Table 2).

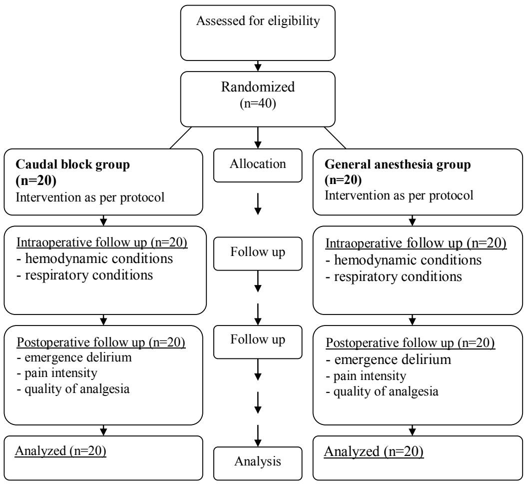

Figure 1. CONSORT flow diagram of the study protocol

Table 1. Demographic characteristics of the patient groups

Parameter	Group CB	Group GA	p
Male/Female No (%)	15/5 (25/ 75)	15/5 (25/ 75)	0.642
Age (year) mean (±standard deviation)	3.50 (±1.53)	3.70 (±1.62)	0.692
Body weight (kg) mean (±standard deviation)	18.75 (±5.486)	19.00 (±8.310)	0.911
Type of surgery No (%)			0.247
Hernia inguinalis	8 (40)	9 (45)	
Cryptochrismus	8 (40)	5 (25)	
Hypospadia	1 (5)	5 (25)	
Phymosis	1 (5)	1 (5)	
Phuniculocella	2 (0)	0 (0)	
ASA status class I/II No (%)	9/11 (45/55)	16/4 (80/20)	0.024
Duration of surgery (minutes) mean (±standard deviation)	43.25 (±35.91)	67.25 (±66.89)	0.168

Group CB, caudal block with propofol and ketamine analgosedation group; Group GA, general endotracheal anaesthesia group; ASA, American Society of Anesthesiologists

Although respiratory stability in the CB group was satisfactory and comparable with the GA group, statistical analysis of the mean SaO_2 showed significant difference between the groups (Table 2).

Table 2. Hemodynamic and respiratory changes according to the groups and time

Parameter	Time	Group CB mean (±SD)	Group GA mean (±SD)	p
SBP				
	t_0	112.10 (±11.37)	111.70 (±9.13)	0.903
	t_1	100.85 (±17.99)	119.88 (±13.71)	0.000
	t_2	93.90 (±7.99)	104.70 (±16.71)	0.015
	t_3	91.05 (±7.67)	104.85 (±14.96)	0.001
DBP				
	t_0	69.10 (±10.42)	68.05 (±9.46)	0.741
	t_1	58.73 (±9.92)	71.10 (±13.36)	0.000
	t_2	51.15 (±6.04)	61.00 (±11.77)	0.002
	t_3	48.80 (±6.31)	62.45 (±13.92)	0.000
MBP				
	t_0	83.85 (±11.68)	82.40 (±10.01)	0.676
	t_1	73.95 (±10.13)	88.08 (±12.63)	0.000
	t_2	65.45 (±6.71)	77.15 (±16.95)	0.007
	t_3	63.55 (±7.52)	75.45 (±10.30)	0.000
HR				
	t_0	105.00 (±18.32)	135.60 (±17.24)	0.000
	t_1	105.25 (±11.88)	118.80 (±16.55)	0.005
	t_2	107.30 (±13.72)	123.20 (±17.54)	0.000
	t_3	98.55 (±11.71)	114.95 (±18.63)	0.002
SaO_2				
	t_0	97.65 (±0.81)	99.25 (±1.16)	0.000
	t_1	96.45 (±0.88)	98.95 (±0.82)	0.000
	t_2	96.15 (±1.18)	99.05 (±1.05)	0.000
	t_3	97.10 (±1.07)	99.65 (±0.58)	0.000

Group CB, caudal block with propofol and ketamine analgosedation group; Group GA, general endotracheal anaesthesia group; SD; standard deviation; SBP, systolic blood pressure; DBP, diastolic blood pressure; MBP, mean blood pressure; SaO_2, saturation with oxygen; t_0, time at preinduction just before administration of propofol; t_1, at the moment of the surgical incision; t_2, 10 minutes after surgical incision; t_3, at the time of skin suturing;

Postoperative ED analysis showed that the mean value of total PAED score remained stable in the CB group, until the change of 13.4% was described in the GA group (p<0.05). A total PAED score were statistically significant lower at 5, 10, 15, 20 and 25 minutes postoperatively in the CB group (Table 3). None of the children required a rescue dose of propofol in the postoperative period.

Table 3. The mean values of the total Paediatric Anaesthesia Emergence Delirium score (PAED) score according to the groups and time

Total PAED score time	Group CB mean (±SD)	Group GA mean (±SD)	p
t_5	0.35 (±0.93)	4.85 (±1.75)	0.00
t_{10}	0.35 (±0.93)	3.60 (±1.18)	0.00
t_{15}	0.30 (±0.92)	2.50 (±1.46)	0.00
t_{20}	0.13 (±0.22)	1.30 (±0.60)	0.01
t_{25}	0.12 (±0.13)	0.55 (±0.42)	0.03
t_{30}	0.30 (±1.55)	0.65 (±0.98)	0.12

Group CB, caudal block with propofol and ketamine analgosedation group; Group GA, general endotracheal anaesthesia group; SD; standard deviation; t_5, 5 minutes postoperatively; t_{10}, 10 minutes postoperatively; t_{15}, 15 minutes postoperatively; t_{20}, 20 minutes postoperatively; t_{25}, 25 minutes postoperatively; t_{30}, 30 minutes postoperatively;

The CHIPPS score was statistically significantly lower at 5, 10, 15, 20 and 25 minutes postoperatively in the CB group (Table 4).

Table 4. The mean values of the total Children's and Infants' Postoperative Pain score (CHIPPS) score according to the groups and time

Total CHIPPS score time	Group CB mean (±SD)	Group GA mean (±SD)	p
t_5	0.00 (±0.00)	2.65 (±1.79)	0.00
t_{10}	0.00 (±0.00)	2.65 (±1.53)	0.00
t_{15}	0.00 (±0.00)	2.00 (±1.48)	0.00
t_{20}	0.05 (±0.22)	1.45 (±1.39)	0.00
t_{25}	0.05 (±0.22)	0.86 (±1.18)	0.00
t_{30}	0.15 (±0.48)	0.55 (±1.09)	0.14
t_{60}	0.10 (±0.30)	0.35 (±0.87)	0.24

Group CB, caudal block with propofol and ketamine analgosedation group; Group GA, general endotracheal anaesthesia group; SD; standard deviation; t_5, 5 minutes postoperatively; t_{10}, 10 minutes postoperatively; t_{15}, 15 minutes postoperatively; t_{20}, 20 minutes postoperatively; t_{25}, 25 minutes postoperatively; t_{30}, 30 minutes postoperatively; t_{60}, 60 minutes postoperatively;

Postoperative analgesia quality results suggested that the average time of first postoperative analgesic request was 10.1 hours in the CB group versus 4.1 hours in the GA group (p<0.001). The average time of the second postoperative analgesic request was 14 hours in the CB group versus 9 hours in the GA group (p=0.01). Six analgesic doses were given in the CB group versus 34 analgesic doses in the GA group in 24 hours postoperatively (p<0.0001). Four (20%) children received one postoperative analgesic dose in the CB group versus six (30%) children in the GA group (p=0.326). One (5%) child had two postoperative analgesic requirements in the CB group compared to 14 (70%) children in the GA group (p<0.001). There were 14 (70%) children without postoperative analgesic request in the CB group versus no one (0%) in the GA group (p<0.000).

DISCUSSION

The presented study evaluated caudal block with analgosedation as an independent anaesthesia technique in children. The results of this study imply that caudal epidural block and simultaneous continuous intravenous analgosedation with propofol and ketamine provided optimal hemodynamic and satisfactory respiratory conditions during surgery, better control of postoperative ED and of postoperative pain compared with general endotracheal anaesthesia in children. This anaesthesia protocol achieved better quality of postoperative analgesia by prolonged average time of the first postoperative analgesic administration and decreased the number of postoperative analgesic requirements.

Awake caudal anaesthesia sometimes does not ensure enough profound motor block of the lower limbs and there is a risk of intraoperative movements (14). Because of these reasons, we used caudal block with analgosedation in spontaneously breathing children as a preferable technique. Propofol and ketamine in analgosedation act complementary and produce fewer adverse effects compared to each drug alone. This combination has several ideal aesthetic properties, e.g. hemodynamic stability, absence of respiratory depression, fast-acting amnestic effects, antiemetic and analgesic effects and pleasant recovery (15). This analgosedation regimen was used in children as a ‘’ketofol’’ mixture or independently as a bolus or as a continuous infusion and in various ratios of the drugs’ doses (16-18). An optimal dose and mixture of propofol and ketamine has not been determined yet. With the intention to keep spontaneously ventilation we used a bolus dose of propofol 1-1.5 mg/kg for anaesthesia induction and continuous infusion of 10mg/kg/h for maintenance of sedation. To obscure analgesia a bolus dose of ketamine 1mg/kg was added before the puncture of caudal block and surgical incision. To the best of our knowledge, this ratio of the propofol and ketamine for analgosedation with caudal block has not been investigated yet.

More stable intraoperative hemodynamic conditions were found in the CB group because the local aesthetic given in the caudal epidural spaces blocked transmission of impulses at the level of nerve axonal membrane, produced sympathectomy and attenuated stress response to surgery (19). The sympathomimetic action of ketamine compensated for the sympatholytic effects of propofol contributed to hemodynamic stability in the CB group (20). In the GA group an increase of blood pressure at the moment of surgical incision was a neurohumoral response to initiation of surgery. Ten minutes after the surgery incision, anaesthesia was maintained by sevoflurane and fentanyl induced vasodilatation and decrease of blood pressure (21,22). Two other studies demonstrated better hemodynamic stability in caudal block compared with general anaesthesia in children (23,24).

In the CB group the patients breathed spontaneously during the surgery without supplemental oxygen flow. Respiratory conditions were acceptable and secure. The absence of capnography monitoring in the CB group could be an objection to inadequate assessment of respiratory conditions. We relied on statements of Zanaboni et al. that continuous infusion of propofol 4-8 mg/kg/h with caudal block maintains spontaneous ventilation and safe capnography in children (25). Any episodes of apnoea, airway obstruction, hypoxia, laryngospasm or bronchospasm were not observed during our study.

The ED is a psychomotor disorder occurring within the first 30 minutes during the recovery from anaesthesia, which includes motor agitation and confusion state without recognition of the surrounding environment (26). Children with ED require additional medication and nursing supervision to prevent self-injuries or surgical site. Our study confirmed earlier finding about the connection of sevoflurane used in general anaesthesia and postoperative ED (27). Although higher total PAED score was recorded in the GA group, there were no patients who needed treatment for ED probably as a consequence of attenuation ED by midazolam premedication (28). Caudal block protects against ED by blocking the sensory input and improving analgesia (29). Caudal block in this study reduced the total PAED score 78-92% compared to the GA group possibly due to additional hypnotic effects of propofol and ketamine in prolongation of awakening time (30).

Caudal block with sedation regimen proposed in this study reached adequate conditions for performing surgery without other analgesic or aesthetic. Ibacache at al. justified that caudal block with analgosedation secured optimal postoperative pain management (31). Duration of postoperative analgesia after caudal block depends on the type of used aesthetic and adjunct medications choose caudal technique, type of surgery and selected group of patients. The analgesic effect reported from 2 hours in the Luz at al. study to 11.5 hours sustained in the Cinar et al. study (32,33). In the presented study the average analgesia time was 10.1 hours in the CB group. De Negri at al. revealed that no patients needed supplemental analgesia after caudal block with 0.125% ropivacaine in children, but caudal block in a continuous epidural infusion was used (34).

The presented study has some limitations. The sample size is relatively small, but we reached statistically significant difference between the groups. Postoperative minor adverse events such as: urinary retention, muscle weakness or postoperative nausea and vomiting were not monitored. Further evaluation is needed. This study was conducted in healthy infants and children with ASA physical status class I and II. Inclusion of high risk infants and children could require to optimize analgosedation protocol.

In conclusion, the results of this study suggest that caudal epidural block with proposed propofol and ketamine analgosedation allows optimal intraoperative hemodynamic and satisfactory respiratory conditions, provides better control of postoperative emergence delirium and postoperative pain compared with general endotracheal anaesthesia in children. Caudal block with propofol and ketamine analgosedation could be recommended for lower abdominal surgery in paediatric population.

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TRANSPARENCY DECLARATIONS

Competing interest: none to declare

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