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Research article

Anesthetic techniques and haemodynamic control for Endoscopic Sinus Surgery: A retrospective analysis and review of literature

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ABSTRACT

Introduction: Bleeding from mucosal edges is known to decrease surgical visibility and increase the risk of complications in Endoscopic sinus surgery (ESS). A variety of strategies, including modifying anesthetic techniques have been proposed to create a bloodless field. A recent survey in anesthesiologist revealed that a vast majority neither use controlled hypotension nor believe that modifying the anesthetic techniques will improve the outcome of ESS. This study investigates the different anesthetic techniques used for ESS and their effect on the haemodynamic variables achieved intra-operatively.

Methods: Data were retrospectively collected from an electronic anesthesia database on 233 consecutive adult patients who underwent endoscopic sinus surgery in a tertiary hospital in Singapore from January 2014 to August 2015 and statistical analysis was performed using SPSS.

Results: Inhaled anesthetics (IA) were used for 93% (49% with morphine or fentanyl, 42% with remifentanil) and total intravenous anesthesia (TIVA) for 7% of the cases respectively. The airway was secured with endotracheal tube in 94.6% and the rest were having LMA. Average Mean Arterial Pressure (MAP) lower than 70 mmHg was achieved in 74.4%. Antihypertensive drugs were used only in 5 cases (2.3%). Distribution of intra operative MAP and Heart rate (HR) were similar among different anesthetic techniques. Lowest MAP and HR achieved were significantly lower in IA with remifentanil use.

Conclusion: Inhaled anesthesia is the preferred maintenance technique used for ESS. The desired MAP range was achieved in about 75% of the cases without needing anti hypertensives. Use of remifentanil reduces the MAP and HR further which might potentially improve the quality of surgical field and the outcome.

1. Introduction

Endoscopic sinus surgery (ESS) is a widely used surgical intervention for treatment of various sinus pathologies [1]. Bleeding from mucosal edges is known to decrease surgical visibility and increase the risk of complications [2]. Optimized surgical field in ESS has been proven to improve surgical outcomes, reduce operating time and lessen blood loss [3]. A variety of strategies have been proposed to create a bloodless field: (a) patient positioning in reverse Trendelenburg to decrease venous congestion of the upper part of the body [4], (b)administration of topical vasoconstrictors to nasal mucosa to decrease capillary bleeding [5], (c) anesthetic modifications like the use of a laryngeal mask airway to decrease hemodynamic responses to endotracheal intubation [6], (d) "high-frequency" jet ventilation to improve venous return [7] and (e) manipulation of ventilator settings to avoid hypercarbia which is a potent vasodilator [8]. Controlled hypotension is another widely used method to reduce the surgical bleeding in otorhinolaryngology, vascular, orthopedic and orthognathic surgeries. Controlled hypotension is defined as a fall in systolic blood pressure (SBP) to 80–90 mmHg, or mean arterial pressure (MAP) to 50–65 mmHg in normotensive patients, or a fall of 30% of MAP in patients with hypertension [9]. The state of hypotension is achieved by reducing the systemic vascular resistance or cardiac output, which is determined by stroke volume and heart rate.

A recent questionnaire survey done in Singapore found that almost 65% do not routinely employ controlled hypotension for ESS and 47% opined that anesthetic technique made no substantial divergence in outcomes of endoscopic sinus surgery [10]. This

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deviation of practice from the recommendation may be due to the ability to achieve MAP within the ranges that minimize surgical bleeding just by being under general anesthesia (GA). Alternatively, the surgeons may be able to achieve good visual fields under normotensive range by non anesthetic techniques. This retrospective study aims to investigate the hemodynamic parameters achieved during surgery, the various anesthetic techniques used for ESS and the outcome of those techniques along the intra operative hemodynamic variables.

2. Methods

This study protocol was developed in accordance to the STROBE (Strengthening the Reporting of Observational studies in Epidemiology) guidelines for reporting cross sectional studies and was approved by the Sing health Centralized Institutional Review Board with the waiver of informed consent (CIRB No 2015/2864).

A total of 233 patients who had general anesthesia for ESS in major operating theatre from January 2014 to August 2015 were identified from an electronic surgical data base. All the patients' electronic pre-anesthetic documents and intra-operative anesthesia charts were reviewed by study members. We searched the following information from the pre-operative anesthetic document; Height, weight, BMI, age, gender, ASA status and history of hypertension and base line mean arterial pressure (MAP) at pre-operative evaluation clinic or at wards during anesthetic review. Electronic anesthesia chart was reviewed in detail to obtain (1) type of anesthesia used for maintenance (Inhalational or TIVA), (2) choice of airway technique used (type of endotracheal tube or Supra glottis airway), (3) drugs used for controlled hypotension (remifentanil, anti-hypertensive), (4) opioids administered and dose, (5) highest/lowest and average MAP and Heart rate (HR) achieved during surgery (excluding hemodynamic changes during induction and emergence of anesthesia), (6) mode of ventilation, (7) average ETCO2 range, (8) duration of anesthesia and (9) duration of surgery.

Average MAP was classified into MAP less than 50, 51–60, 61–70, 71–80 and above 80 mmHg. Average HR was categorized to HR under 40, 41–50, 51–60, 61–70 and 71–80 and above 80 beats per minute. Average ETCO2 was classified to ETCO2 under 30, 30–35, 36–40, 41–45 and above 45 mmHg. The ETCO2 was documented as a graph in the electronic anesthesia document. From the ETCO2 trace, tentative baseline ETCO2 was calculated for each 15-min time block, and the intra-operative average was derived from the values of 15 min blocks.

3. Statistical methods

Statistical analysis was performed using SPSS for Mac version 20.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were reported as mean values (SD). Categorical variables were reported as numbers (percentage). Normality for continuous variables into groups was determined by the Shapiro-Wilk test. One-way analysis of variance (ANOVA), Dunnett's test and student's *t*-test were applied for comparison of continuous variables between the examined groups. Pearson chi-square test was applied for comparison of categorical variables among studied groups. A p value below 0.05 was considered statistically significant.

4. Results

We reviewed 233 anesthetic documents and nine cases were excluded. Of those, eight cases were due to wrong surgical coding and one due to cancellation of surgery after induction of anesthesia. Data were obtained from 224 cases and used for the analysis.

The average age (SD) of our patient cohort was 49 (15) years with 56% males and remaining 44% patients were females. The majority of the patients (60.7%) belonged to the American Society of Anesthetists (ASA) 2 class, while 33.5% were ASA 1 and 5.8% ASA 3 respectively. Seventy (31.2%) patients were known to have hypertension with the mean (SD) MAP of 98.7 (12.2) mmHg at the time of pre-operative visit, while the rest (68.7%) of the normotensive patient had the mean (SD) MAP was 91.03 (12.1). Mean (SD) duration of anesthesia was 122.88 (51.4) min and the surgery was 91.03 (50.9) min (Table 1).

4.1. Anesthetic techniques

The airway was secured with endotracheal intubation in 212 (94.6%) patients, while the laryngeal mask airway was used in 12 (5.4%). The most popular choice of the endotracheal tube (ETT) used was armored tube, documented in 149 (66.5%) cases. RAE (Ring, Adair and Elwyn) preformed south tube and normal Portex ETT were used in 62 (27.7%) and one (0.45%) case respectively. Volume controlled ventilation was chosen in 214 (95.5%) patients, pressure control ventilation in six (2.7%) patients. Two (0.89%) patients each were ventilated using synchronized intermittent mandatory ventilation (SIMV) mode and spontaneous respiration. Anesthesia was maintained with inhaled anesthetic (IA) alone in 110 (49.1%) patients and a combination of IA and remifentanil (IA-R) in 94 (42%) patients. A combination of Total intravenous anesthesia (TIVA) with propofol and remifentanil was used in 16 (7.4%) and IA, propofol and remifentanil were administered to 4 (1.8%) patients. Almost all the patients (99.5%) received at least one opioid except one patient who didn't receive any (Table 2).

4.2. Intra-operative hemodynamic variables

The mean (SD) of lowest and highest MAP values were 55.57 (8.88) mmHg and 82.59 (13.7) mmHg respectively. The average MAP was 70 mmHg or below in 167 (74.55%) and above 70 mmHg in 57 (25.45%) cases (Fig. 1).

Table 1
Summary of patient demographic data and health status.

Characteristics	Mean (SD)
Age (years)	49.37 (15.14)
Height (m)	1.64 (0.10)
Weight (kg)	66.62 (14.08)
BMI (kg m^{-2})	24.65 (4.59)
Duration of anesthesia (min)	122.88 (51.4)
Duration of surgery (min)	96.48 (50.9)
Average baseline MAP (mmHg)	
Patients with known hypertension[a]	98.76 (12.26)
Patients without hypertension	91.03 (12.19)
Characteristics	**Number (%)**
ASA score	
1	75 (33.48%)
2	136 (60.71%)
3	13 (5.80%)
Gender	
Male	126 (56.25%)
Female	98 (43.75%)
History of hypertension	
Yes	70 (31.25%)
No	154 (68.75%)

Data is presented as mean (standard deviation) or number (Percentage).
BMI – body mass index, ASA score – American Society of Anaesthesiologists' classification of Physical Health, MAP – mean arterial pressure.
[a] Mean of baseline MAP (mmHg) in patents already diagnosed to have hypertension.

Table 2
Summary of anesthetic techniques.

Characteristics	Number (%)
GA techniques	
Inhaled anesthetic	110 (49.11%)
Inhaled anesthetic with remifentanil	94 (41.96%)
IV propofol with remifentanil	16 (7.14%)
Inhaled anesthetic + IV Propofol + Remifentanil	4 (1.79%)
Airway technique	
ETT	212 (94.64%)
Normal	1 (0.45%)
RAE	62 (27.68%)
Armoured	149 (66.52%)
LMA	12 (5.36%)
Classical	6 (2.68%)
Proseal	1 (0.45%)
Supreme	4 (1.79%)
Reinforced	1 (0.45%)
Mode of ventilation	
VCV	214 (95.54%)
PCV	6 (2.68%)
SIMV	2 (0.89%)
Spontaneous	2 (0.89%)
Intra-operative use of anti-hypertensive	
No	219 (97.77%)
Yes	5 (2.23%)
Labetalol	4 (1.79%)
Esmolol	1 (0.45%)
Intra-operative opioids	
No	1 (0.45%)
Yes	223 (99.55%)
Morphine only	28 (12.50%)
Fentanyl only	13 (5.80%)
Remifentanil only	8 (3.57%)
Fentanyl + morphine	71 (31.70%)
Remifentanil + fentanyl	3 (1.34%)
Remifentanil + morphine	92 (41.07%)
Morphine + fentanyl + remifentanil	8 (3.57%)

Data is presented as number (Percentage).
ETT – Endotracheal tube, LMA – Laryngeal mask airway, VCV – Volume Controlled Ventilation, PCV – Pressure Controlled Ventilation, SMIV – Synchronized Mandatory Intermittent Ventilation.

Mean (SD) of lowest and highest intraoperative HR values were 57.7 (10.18) and 75.1 (12.81) beats per minute respectively. Average intraoperative HR was below 70 in 175 (78.12%) and 70 or above in 49 (21.88%) patients (Fig. 2).

The MAP ranges were classified into 5 groups and the distribution of MAP ranges were comparable among the three anesthetic techniques (p value 0.26). Similarly, there was no difference in distribution of heart rate ranges among 3 groups of anesthetic techniques used. When the subgroups of MAPs were analyzed individually, they remained comparable among the 3 anesthetic techniques. By contrast means of lowest and highest intra-operative MAP and means of lowest and highest HR differed statistically between the 3 anesthetic techniques (Table 3). Dunnett's test was done to explore the difference in extremes of MAP and HR between the anesthetic techniques. We found a significant difference only between IA and IA-R and the other groups were similar with regards to highest and lowest MAP and HR.

Distributions of MAP ranges and HR ranges were comparable between hypertensive and normotensive subjects. There was no difference in means of highest and lowest MAP and highest and lowest HR between patients known to hypertension and normotensive (Table 4).

5. Discussion

This retrospective cross sectional study found that IA with morphine or fentanyl is the most popular anesthetic practice (49%) for ESS followed by IA-R (42%) and TIVA (7%). There was no significant difference in the average intra-operative MAP or HR among these 3 different practices. However, combining remifentanil to IA significantly reduced the lowest MAP and HR during the surgery.

IA and TIVA were given to 93% and 7% respectively in this cohort of patients undergoing ESS. This is almost similar to our previous finding of only 10.5% of the anesthesiologists in Singapore public sector preferred to use TIVA for ESS [9]. The airway was secured with ETT in 94.6% despite of the added benefits of LMA such as smooth emergence, reduced hemodynamic volatility and a reduction in the opioid requirement to maintain the MAP in hypotensive range [6]. This could imply an institutional practice or simply that the anesthesiologists were more concerned about the dangerous consequences of airway contamination with gastric contents [11] over the potential benefits of using LMA.

Moderate hypotension is defined as MAP of 60–70 mmHg, which has been shown by many studies to provide good surgical outcomes without compromising the patient safety in ESS [12,13]. We found that the target MAP for ESS (below 70 mmHg) was achieved in 164 subjects (74.4%). This MAP target was achieved in 73% of IA, 82% of the IA-R and 75% of TIVA group respectively. Antihypertensive were administered only in 5 cases (2.3%). Ability to achieving required range of MAP with adequate anesthesia and analgesia without using antihypertensives in our patient cohort justifies the reason for 65% of anesthetists do not routinely employ controlled hypotension for ESS in the survey

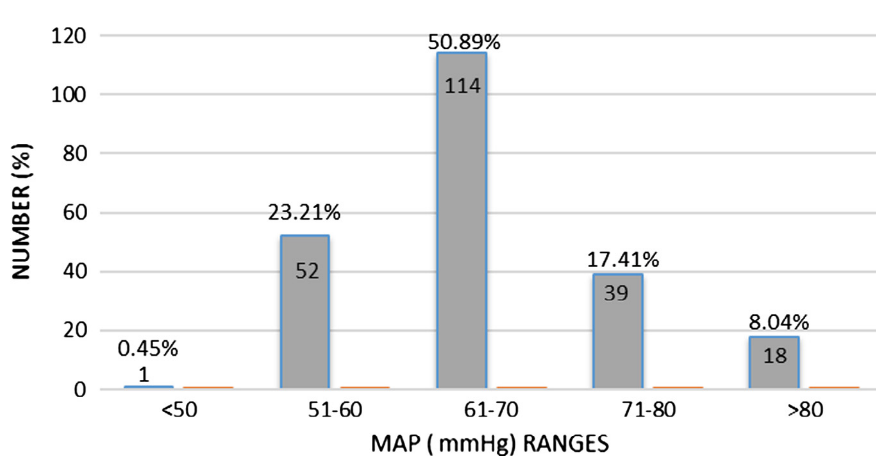

Figure 1. Distribution of intra-operative MAP ranges.

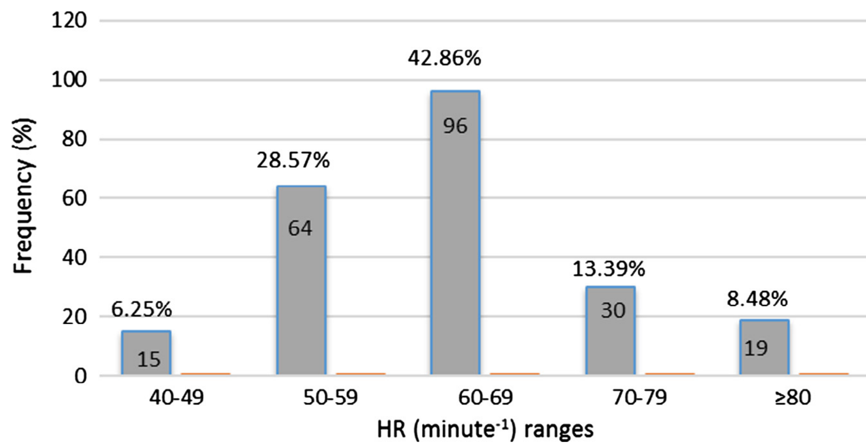

Figure 2. Distribution of intra-operative HR ranges.

Table 3
Comparison of patient's hemodynamic variables between different anesthetic techniques.

Anesthesia techniques Hemodynamic variable	IA alone (N = 110) Subtotal no. (%)	IA with remifentanil (N = 94) Subtotal no. (%)	IV propofol with remifentanil (N = 16) Subtotal no. (%)	P values
Average MAP ranges				0.226 (over all)
<50	0 (0%)	1 (1.06%)	0 (0%)	0.510
51–60	24 (21.82%)	25 (26.60%)	2 (12.50%)	0.416
61–70	49 (44.55%)	52 (55.32%)	10 (62.50%)	0.187
71–80	25 (22.73%)	12 (12.77%)	2 (12.50%)	0.152
>80	12 (10.91%)	4 (4.26%)	2 (12.50%)	0.181
Average Heart rate ranges				0.137 (over all)
40–49	5 (4.55%)	10 (10.64%)	0 (0%)	
50–59	27 (24.55%)	33 (35.11%)	4 (25.00%)	
60–69	49 (44.55%)	35 (31.82%)	8 (50.00%)	
70–79	16 (14.55%)	10 (10.64%)	4 (25.00%)	
⩾80	13 (11.82%)	6 (6.38%)	0 (0%)	
Hemodynamic variable	Mean (SD)	Mean (SD)	Mean (SD)	P values
Mean of lowest MAP	57.22 (9.35)	53.77 (8.61)	54.13 (4.69)	**0.017**
Mean of highest MAP	84.91 (14.06)	79.47 (12.92)	83.81 (12.31)	**0.016**
Mean of lowest HR	59.41 (10.40)	55.50 (10.35)	58.50 (5.76)	**0.023**
Mean of highest HR	77.39 (13.96)	71.98 (11.42)	78.25 (10.04)	**0.007**

Significance of bold values is P < 0.05.
Data is presented as mean (standard deviation) or number (Proportion).
MAP – Mean Arterial Pressure (mmHg); Average MAP during intra-operative period excluding induction and emergence.
HR – Heart Rate Average (min^{-1}); HR during intra-operative period excluding induction and emergence.

[9]. Possible contributing factors to achieve this could be the reverse Trendelenburg position, smooth induction and intubation techniques with minimal sympathetic stimulation, local anesthetic infiltration to surgical fields and minimal surgical stimulation [14]. However, achieving MAP in the range of controlled hypotension with IA may not necessarily improve the quality of visual field [2] or reduce the blood loss. Higher concentration of IA causes peripheral vasodilation [15] systemically and locally within the nasal mucosa in a dose dependant manner. This can possibly result in tachycardia, and increase capillary bleeding despite that systolic blood pressure is low [16].

Furthermore, this study showed that combining remifentanil infusion with IA decreases the MAP below 70 mmHg in 17% of patients and maintains HR below 60 beats/minute in 11% of patients. The overall effect of remifentanil on the quality of the surgical field and blood loss is proven to be significant [17,18]. This is attributed to its hypotensive and bradycardic effects without the causing peripheral vasodilatation [19]. For this reason, remifentanil could be considered as a first line agent to achieve hypotensive anesthesia for head and neck surgeries. However, if IA is used to titrate the MAP, inappropriate usage of higher doses of IA could be a source of additional vasodilation in the surgical field, predisposing to worse visual field scores [3,13]. The average and extremes of MAP or HR of TIVA group were comparable to IA and IA-R group in our patient cohort. However, the synergistic effect of remifentanil with propofol as TIVA [20] is shown to have lower MAP [2] and HR [3] compared to IA (sevoflurane) in ESS. We couldn't demonstrate this due to less number of patients in TIVA group.

A recent study evaluating the patients undergoing hypotensive anesthesia for ESS found that reducing MAP improved bleeding scores, a strong association with reduction of middle cerebral artery blood flow velocity (Vmca) as measured by transcranial Doppler ultrasonography [21]. The results from this study suggested that based on Vmca flows, reducing MAP below 60 mmHg may increase cerebral ischemia risk. Comparisons of intra-operative MAP range between known hypertensives and normotensives in our cohort showed that average MAP was below 60 mmHg in 18.5% of hypertensives and 26% of normotensives. This would illustrate that the anesthesiologist were aware of the possible risk of cerebral ischemia and practice cautiously in the hypertensive group who are at higher risk. However, if hypotensive

Table 4
Comparison of hemodynamic variables between hypertensive and normotensive patients.

Known status Hemodynamic variable	Hypertensive (N=70) Subtotal no. (%)	Normotensive (N = 154) Subtotal no. (%)	P values
MAP ranges			0.385 (over all)
<50	1 (1.43%)	0 (0%)	0.137
51–60	12 (17.14%)	40 (25.97%)	0.147
61–70	38 (54.29%)	76 (49.35%)	0.493
71–80	13 (18.57%)	26 (16.88%)	0.758
>80	6 (8.57%)	12 (7.79%)	0.841
Heart rate ranges			0.250
40–49	6 (8.57%)	9 (5.84%)	
50–59	26 (37.14%)	38 (24.68%)	
60–69	27 (38.57%)	69 (44.81%)	
70–79	7 (10.00%)	23 (14.94%)	
⩾80	4 (5.71%)	15 (9.74%)	
Hemodynamic variable	Mean (SD)	Mean (SD)	P values
Mean of lowest MAP	56.59 (8.44)	55.10 (9.06)	0.248
Mean of highest MAP	84.69 (13.50)	81.64 (13.73)	0.124
Mean of lowest HR	55.87 (10.24)	58.57 (10.07)	0.066
Mean of highest HR	73.59 (13.12)	75.80 (12.65)	0.232

Data is presented as mean (standard deviation) or number (Proportion).
MAP – Mean Arterial Pressure (mmHg); Average MAP during intra-operative period excluding induction and emergence.
HR – Heart Rate (min^{-1}); Average HR during intra-operative period excluding induction and emergence.

anesthesia (MAP below 60 mmHg) is required to improve the surgical outcomes, monitoring cerebral function should be attempted especially in those at higher risk for cerebral ischemia. Continuous monitoring of cerebral oxygenation, such as Near Infrared Spectroscopy (NIRS), could be a feasible option here.

This study has several limitations. Firstly the data are from a single institution and the practices may be differ in other centres. However the proportions of anesthetic techniques used in our study are similar to the findings of a local survey done in all the public health institutions [9]. Furthermore our institution has anesthesiologists trained locally and internationally and who practice a diverse range of anesthetic techniques for ESS. Secondly, this is a retrospective cross sectional study and it may not be possible to identify or address all the anesthetic and surgical confounds influencing the outcomes such as Minimum alveolar concentration (MAC) of inhalation anesthetics, remifentanil infusion rate and different surgical techniques used to reduce the blood loss. However, our study was done to explore the effects of anesthetic techniques on intra-operative hemodynamic variables. We believe our retrospective study with a good sample size (224) is adequate to answer the study question. Thirdly, there was a significant difference in the distribution of cases among different anesthetic practices and only a few patients (14) received TIVA. This makes it difficult to derive conclusions using data from the TIVA group. Nevertheless, this depicts the real world practice of anesthesia for ESS. Fourthly, there is no record of surgeon satisfaction with the amount of bleeding and the quality of the visual field. However, it would be unthinkable that the non-practice of controlled hypotension at an institution level would have gone unnoticed and uncorrected if visual field quality suffered.

6. Conclusion

Inhalation anesthesia is the preferred maintenance technique used for ESS. MAP in the moderate hypotensive range or below is achieved in almost 3 out of 4 cases using the inhalation technique with fentanyl or morphine. Using remifentanil further decreases the MAP and HR which could ultimately lead to a better surgical outcome. However, we are unable to comment on the effects this finding on the quality of the surgical field and blood loss.

Conflicts of interest

None.

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Contribution

Suhitharan T participated in study design, collected the data and prepared the manuscript.

Sangeetha S participated in study design and collected the data.

Kothandan H participated in study design and prepared the manuscript.

Esther DY participated in study design and analyzed the data.

Ho VK participated in study design and prepared the manuscript.

Attestation

Suhitharan T approved the final manuscript and attests to the integrity of the original data and the analysis reported in the manuscript.

Sangeetha S approved the final manuscript and attests to the integrity of the original data and the analysis reported in the manuscript.

Kothandan H approved the final manuscript and attests to the integrity of the original data and the analysis reported in the manuscript.

Esther DY approved the final manuscript and attests to the integrity of the original data and the analysis reported in the manuscript.

Ho VK approved the final manuscript and attests to the integrity of the original data and the analysis reported in the manuscript.

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