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Comparing the effects of magnesium sulfate and lidocaine spray on hemodynamic changes caused by laryngoscopy and tracheal intubation: a randomized clinical trial

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Abstract

Aim This study aims at comparing the impact of Magnesium Sulfate and Lidocaine sprays on hemodynamic changes after laryngoscopy and tracheal intubation.

Design This double-blind clinical trial (code IRCT20230719058846N1) was conducted on the patients undergoing elective surgery in the city of Karaj.

Methods A total of 100 patients, aged 18 to 40 years and classified as ASA I or II, who were candidates for elective surgery, were randomly assigned to two equal groups. Prior to intubation, patients received lidocaine spray (5 puffs of Lidocaine 10%) in one group, and magnesium sulfate spray (5 puffs of Magnesium 20%) in the other. Induction of anesthesia was the same in both groups. Patients' hemodynamic statuses were measured and compared once before the intubation and also 1, 3, 5, 7 and 10 min after it.

Results Before the intervention, there was no statistically significant difference between the two groups in terms of demographic and hemodynamic variables ($P < 0.05$). The results showed that the systolic blood pressure at minutes 3, 5, and 7 was significantly lower among the patients receiving magnesium than those receiving lidocaine ($P < 0.05$). Other hemodynamic variables were not statistically different between the two groups ($P < 0.05$).

Conclusion Based on the findings of the present study, magnesium sulfate spray is more effective than lidocaine in controlling hemodynamic complications. Therefore, it can be used to reduce hemodynamic complications following intubation. However, it may be associated with tachycardia, which needs to be taken into account.

Keywords Endotracheal intubation, Hemodynamic response, Laryngoscopy, Lidocaine spray, Magnesium sulfate spray

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Introduction

Tracheal intubation is an essential part of safe general anesthesia. This technique is essential in maintaining an open upper airway, ensuring proper ventilation, reducing the risk of aspiration, and administering inhalational anesthetics for the continuation of anesthesia [1]. However, as a painful stimulation, this procedure results in intense physiological responses in the form of autonomic reflexes and activation of the brainstem. Sensory impulses originating from the root of the tongue, epiglottis, and trachea are transmitted to the brainstem, stimulating the vasomotor and cardiovascular systems, leading to increased hemodynamic indicators. Reflex vasoconstriction manifests within a few seconds, followed by sinus tachycardia, which reaches its peak within two minutes and lasts for five minutes [2].

In general, the strong sympathoadrenal response leads to an increased heart rate and arterial pressure, as well as a raised level of plasma catecholamines [2]. The mechanism behind these changes involves vasoconstriction and increased myocardial activity, accompanied by an increased demand for coronary blood flow. Narrowed coronary arteries may not tolerate the increased pressure and parts of the myocardium may not receive enough oxygen [3]. These responses are especially threatening and dangerous in people who have coronary insufficiency or hypertension. Moreover, a significant risk increase is correlated with left ventricular failure, renal failure, bleeding during surgery, intracerebral bleeding, and myocardial ischemia in patients [4].

The increase in blood pressure and heart rate following intubation is variable and unpredictable [3]. Sometimes hemodynamic changes are not identified and managed in time, becoming life-threatening in some cases and leading to the cancellation of surgery [4]. Therefore, it is essential to provide solutions that can minimize these responses.

To prevent reflex responses, there are various methods that include increasing the depth of anesthesia or concentration of inhalational anesthetics, administration of short-acting opioids, lidocaine, and blockers, and minimizing laryngoscopy time (less than 15 s). Furthermore, magnesium sulfate can be effective in mitigating these reflex responses with its direct vasodilatory effect on coronary vessels and inhibiting the release of catecholamines. In addition, magnesium blocks NMDA channels in a voltage-dependent manner, and NMDA receptor blocking enhances analgesia [5]. Another method that is used in some hospitals in Iran to reduce the duration of labor is applying magnesium sulfate on the cervix. This method has been used empirically for many years, with few studies conducted on it [6].

In addition to safe intubation, minimizing complications, enhancing simplicity, and ensuring cost-effectiveness, it is crucial to implement the most useful and effective approach to reduce reflex responses in the patients undergoing elective surgery. Magnesium sulfate spray can be recognized a better alternative to lidocaine due to its more proper cost, the ease of use, and reduced complications.

Purpose

Little research has been done on the impact of lidocaine and magnesium sulfate spray on hemodynamic changes caused by tracheal intubation [7, 8]. Moreover, comparing the application of magnesium and lidocaine by researchers has yielded controversial results. Therefore, the authors of this study decided to investigate and compare the hemodynamic changes caused by tracheal intubation using lidocaine and magnesium sulfate spray to determine whether magnesium sulfate spray can be a suitable alternative to lidocaine in controlling these changes.

Methods

Trial design

This clinical trial study with one intervention and one control group was conducted on the patients undergoing elective surgery from December 2023 to March 2024, Karaj, Iran.

Settings

This study was conducted in Madani Hospital affiliated to Alborz University of Medical Sciences. This hospital is the largest surgery and trauma specialty and subspecialty center in Karaj, where patients who need surgery are referred to this center.

Sample size

The sample size was determined to be 48 for each group according to the results of the study by Hamzaei et al., using G-Power software, with a research power of 80% and a type I error rate of 0.05. It was then increased to 50 samples per group to account for possible subject attrition and to enhance the research power. Therefore, a total of 100 subjects we included in the study [9].

Participants

The research population comprised patients undergoing elective orthopedic and general surgery. The inclusion criteria included patients aged 18 to 40 years with ASA Class I or II based on physical and cardiovascular examination. Other inclusion criteria comprised BMI between 19 and 25 and a Mallampati score of class I or II. The exclusion criteria were patients with a history of high blood pressure, sensitivity to magnesium sulfate or lidocaine, and smoking. Also, patients with anticipated difficulties in intubation were excluded from the study.

In this study, samples were collected through convenient consecutive sampling. Two sets of identical cards labeled A and B (50 cards each) were placed in a pot. The letters inside the cards were hidden from the subjects. Each subject took a card from inside the pot, based on which he/she was assigned to the lidocaine or magnesium sulfate group. The cards were selected without permutation. Once the card was removed, it did not return to the pot. The subjects were not aware of the letters inside the cards or what each letter represented regarding the studied medicines. Furthermore, the participants in the study did not communicate with each other.

Procedures and interventions

The protocol for conducting this research was approved by the ethics committee of Alborz University of Medical Sciences. The researchers prepared a list of patients who met the inclusion criteria and collected their information after obtaining the required permits and the ethics code (IR.ABZUMS.REC.1402.086) in coordination with the operating room and hospital authorities. Patients' information including age, gender, and body mass index was extracted from their documents. Hemodynamic variables were also measured based on blood pressure, heart rate, and blood oxygen saturation using a monitoring device (Zoncare/PM-7000D) and pulse oximeter (Jumper jpd-500e) by an anesthesiologist who was unaware of patients' assignment to research groups.

Patients were then briefed about the study design, objectives, and methodology. Written consent was obtained after participants' acceptance. They were also assured that they could withdraw from the study at any time.

The intervention was done as follows

Initially, routine anesthesia methods, including sedatives, narcotics, hypnotics, and relaxants, were used for patients in both groups. Thus, midazolam at a dose of 0.01 mg/kg, fentanyl at 3 μg/kg, propofol at 1.5 mg/kg, and atracurium at 1 mg/kg were administered for induction. Afterwards, in one group of patients, 5 puffs of 10% lidocaine spray were applied to the throat, with each puff containing 10 mg of lidocaine. After 3 min, the patients underwent laryngoscopy and were intubated. Intubation was performed by a skilled anesthesiologist and took less than 15 s. Endotracheal tubes No. 8 for men and No. 7 for women were used with a Macintosh laryngoscope blade No. 4. In the other group, the same steps were followed, but 20% magnesium sulfate spray was used instead of lidocaine.

In all patients, airway assessment was performed according to the Mallampati score, with all patients classified as either class I or II. In other words, all patients were in good condition for intubation.

Outcome measure

The primary aim in this study was to investigate the changes in hemodynamic status after intubation in patients undergoing surgery. After laryngoscopy and endotracheal intubation, changes in heart rate, blood pressure (systolic and diastolic) and SpO_2 were measured and recorded at 1, 3, 5, 7 and 10 min following the procedure.

Blinding

Both sprays had an identical appearance and the case was covered so that those performing the procedure and recording the results were unaware of the substance inside.

Data analysis

Frequency (percentage) was used to describe qualitative variables and mean (standard deviation) was used for quantitative variables. SPSS V24 was employed for data analysis. The chi-square test was used to compare qualitative variables and either the paired t-test (for before-after comparisons within each group) or the independent t-test (for comparison between two groups) was used for quantitative variables. A significance level of <0.05 was considered.

Results

In this clinical trial study, 100 patients undergoing elective orthopedic and general surgery who met the inclusion criteria were randomly assigned to two groups of 50 (test group and control group), and were then examined for the intended outcome (Fig. 1). Details related to demographic variables are provided in Table 1.

Lidocaine group

Systolic blood pressure A significant increase was observed at minute 1 after laryngoscopy compared to pre-intubation measurements (118.9 ± 10.5). It then gradually decreased, but the difference was not significant compared to pre-intervention readings.

Diastolic blood pressure At the first and third minutes, the mean amount of this variable increased compared to pre-intervention measurements (75.4 ± 20.1). However, this increase was not statistically significant. A significant decrease was observed thereafter. It increased at the 10th minute, but it was not statistically significant.

Pulse rate and blood oxygen saturation level The changes were not statistically significant during the studied period. More details are shown in Table 2.

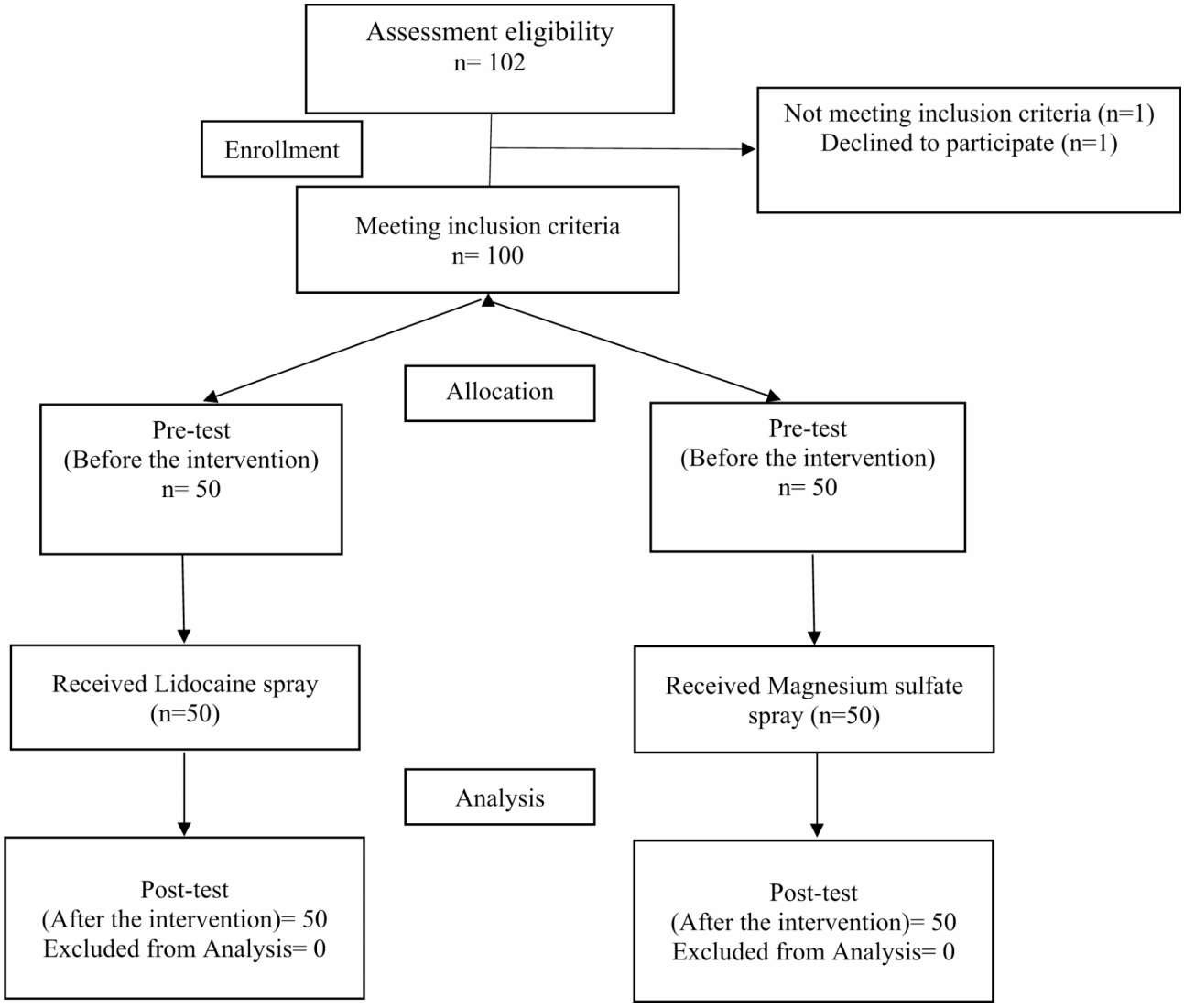

Fig. 1 Diagram of CONSORT

Table 1 A comparison of patients' demographic information and hemodynamic status prior to the intervention

Variable		Lidocaine *n* = 50 (%)	Magnesium Sulfate *n* = 50 (%)	*P*
Gender	**Male**	25 (50.0)	33 (66.0)	*0.105
	Female	25 (50.0)	17 (34.0)	
Age (years)		31.0 ± 6.60	32.9 ± 6.5	≠0.150
Body Mass Index (kg/m^2)		23.7 ± 1.5	23.9 ± 1.4	≠0.640
Systolic Pressure (mm Hg)		118.9 ± 10.5	116.5 ± 11.5	≠0.287
Diastolic Pressure (mm Hg)		75.4 ± 20.1	69.9 ± 13.2	≠0.114
Heart Rate (beats/min)		88.1 ± 19.2	85.3 ± 18.0	≠0.460
SpO_2		96.4 ± 5.1	97.6 ± 2.0	≠0.121

Note: *: chi2, ≠: t-test

Magnesium sulfate group

Systolic blood pressure At 1 and 3 min after laryngoscopy, a significant increase was observed compared to pre-laryngoscopy measurements (116.5 ± 11.5). This was followed by a gradual, significant decline starting from the 5th minute. There was another increase at the 10th minute which was not significant.

Diastolic blood pressure At the first and third minutes, the mean level of this variable increased compared to pre-

Table 2 A comparison of hemodynamic changes after laryngoscopy between the two groups

Variable		Minute 1	Minute 3	Minute 5	Minute 7	Minute 10
Systolic pressure	Lidocaine	131.1 ± 20.7	121.5 ± 16.8	116.1 ± 16.7	115.8 ± 22.8	120.2 ± 21.5
	Magnesium	126.8 ± 24.0	112.1 ± 22.0	101.9 ± 18.3	104.1 ± 25.0	112.4 ± 22.6
P(t-test)		**0.346**	**0.018**	**0.001**	**0.015**	**0.080**
Diastolic pressure	Lidocaine	77.7 ± 17.4	75.6 ± 17.8	66.4 ± 17.0	64.8 ± 15.4	68.6 ± 19.5
	Magnesium	74.2 ± 18.2	68.4 ± 21.4	67.9 ± 18.0	66.9 ± 21.0	67.0 ± 26.0
P(t-test)		**0.336**	**0.067**	**0.664**	**0.559**	**0.934**
Heart rate	Lidocaine	91.2 ± 21.4	89.8 ± 21.2	88.7 ± 19.9	87.5 ± 17.8	85.6 ± 16.2
	Magnesium	91.9 ± 23.3	86.7 ± 18.0	86.7 ± 17.9	90.0 ± 16.5	85.8 ± 21.4
P(t-test)		**0.869**	**0.427**	**0.598**	**0.464**	**0.958**
Blood oxygen saturation level	Lidocaine	96.4 ± 5.1	97.1 ± 4.1	96.1 ± 5.1	96.7 ± 3.8	94.4 ± 12.9
	Magnesium	97.6 ± 2.0	97.6 ± 1.9	97.1 ± 2.2	97.2 ± 2.3	96.6 ± 2.7
P(t-test)		**0.121**	**0.367**	**0.226**	**0.429**	**0.239**

intervention readings (69.9 ± 13.2), but the increase was not statistically significant. Then it decreased, which was still insignificant.

Heart rate It initially increased, but decreased from the 3rd minute. However, there was a significant increase at the 7th minute.

Blood oxygen saturation level Changes were not statistically significant during the investigated period.

In general, the results showed that systolic blood pressure at the 3rd, 5th, and 7th minutes was significantly lower in the magnesium sulfate group compared to the lidocaine group. Other hemodynamic variables did not show statistically significant differences between the two groups (Table 2).

Discussion

Hemodynamic changes following airway stimulation are a common phenomenon, and managing these changes is important to reduce systemic complications [10]. This clinical trial was conducted to compare the effects of lidocaine and magnesium sulfate spray on hemodynamic changes caused by laryngoscopy and tracheal intubation in the patients undergoing elective surgery. In the literature review, no previous studies were found that focused on the impact of magnesium sulfate and lidocaine spray on hemodynamic changes caused by laryngoscopy and tracheal intubation. Therefore, this is the first study conducted on Iranian patients.

Based on the present study, no statistically significant differences were observed between the two groups in terms of demographic variables and basic hemodynamic variables. This increases the accuracy of the results and facilitates the investigation of the changes caused by applying lidocaine and magnesium sulfate spray, leading to greater generalizability.

As the findings of the present study also showed, adverse hemodynamic changes such as increased heart rate and increased blood pressure are common after laryngoscopy [11]. In the present study, these changes were observed within the first three minutes, especially in the lidocaine group. Increased heart rate or tachycardia is one of the hemodynamic changes following laryngoscopy, and its occurrence is higher in some patients, including the elderly and patients with uncontrolled blood pressure [12]. In addition, increased blood pressure is one of the hemodynamic changes following this anesthesia technique, and its intensity may vary according to the patient's condition. The exact mechanism of these hemodynamic changes after laryngoscopy and intubation is not fully known. However, most of them are attributed to reflex sympathetic discharge caused by stimulation of the upper respiratory tract [13]. The studies by Hamzei et al. [9] and Çardaközü et al. [11] were in line with the findings of this study, observing increased blood pressure and increased heart rate after intubation.

Several medications and techniques are used to address the hemodynamic complications of laryngoscopy, including oropharyngeal local anesthesia, intralaryngeal injection of lidocaine before intubation, intravenous lidocaine, deep ventilation with inhaled agents prior to these procedures, opioids, vasodilators such as intravenous magnesium sulfate, adrenergic blocking agents, and calcium channel blockers. These interventions have been associated with varying outcomes, and it is still not possible to provide a definitive opinion on this matter [8, 14].

In the present study, it was observed that both lidocaine and magnesium sulfate can control hemodynamic changes, particularly heart rate and blood oxygen levels; however, compared to lidocaine, magnesium sulfate is more effective and acts faster in controlling systolic blood pressure. Despite this, an increased heart rate was observed in these patients in the 7th minute, raising the risk of tachycardia.

In a similar study that investigated the effect of lidocaine and magnesium sulfate in the hemodynamic response to tracheal intubation, it was found that HR

and BP increased after laryngoscopy and intubation compared to baseline values. The magnesium group showed a statistically significant increase in systolic and diastolic blood pressure values after intubation. Among patients receiving magnesium sulfate, three (12%) had high blood pressure, while in the group of patients receiving lidocaine, only one (4%) had high blood pressure, which was not statistically significant [15]. In the present study, the mean heart rate in the 1st minute after intubation was not significantly different between the two groups. However, in the 2nd, 3rd, and 4th minutes, the decrease in heart rate was slower in the magnesium group compared to the lidocaine group. By the 5th minute, the mean heart rate in both groups returned to the initial value. The differences between the results of the present study and those of other studies may be due to variations in patients' ages. The subjects of this study were between 20 and 40 years of age.

Regarding the impact of these two drugs on the hemodynamic response following intubation, several studies with different designs have been conducted, yielding varying results [15–17]. Magnesium has both vasodilatory and antiarrhythmic effects, while lidocaine is a local anesthetic that can reduce airway sensitivity [18]. Magnesium sulfate acts faster and influences blood pressure within the 1st minute, whereas lidocaine takes effect after several minutes. In the present study, blood pressure decreased more rapidly in patients receiving magnesium sulfate, consistent with the findings of several other studies [19].

In the study by Misganaw et al. [18], no statistically significant difference was observed in the mean heart rate between the magnesium sulfate and lidocaine groups at any time interval after intubation. However, a statistically significant increase in mean heart rate compared to the baseline value was observed in the magnesium sulfate group, the lidocaine group, and the control group at all time intervals following intubation. Bandey and Singh [20] also reported similar findings. Furthermore, the results of the present study are consistent with those of the study by Bhalerao et al., in which no significant difference was observed in heart rate changes between the magnesium and lidocaine groups during the study period [21].

The ability of magnesium ion to inhibit catecholamines release has been known for a long time, so it has been considered for reducing hemodynamic changes following laryngoscopy and intubation in order to minimize these adverse complications, which are life-threatening in some cases. The results of the study by Min et al. [22] showed that in those who received magnesium, the increase in systolic blood pressure was significant compared to the baseline value in the 1st minute. Whereas, in the lidocaine group, this increase within the first two minutes was insignificant compared to the baseline value. Obviously, intubation causes an increase in systolic pressure, but these changes gradually return to normal. Therefore, it is important to manage it in the first minutes with effective drugs. Although diastolic blood pressure increased after intubation in both groups, this increase was not significant in any of the groups compared to the baseline value. These results can be explained by the fact that magnesium causes vasodilation both directly and indirectly by blocking the ganglia and inhibiting the release of catecholamines. The difference in mean systolic blood pressure between the two groups can be explained by the impact of magnesium on the transient reduction of systemic vascular resistance in conjunction with reduced arterial pressure.

Regarding the impact of lidocaine spray on hemodynamic changes following intubation, the results of various studies are controversial. Some studies have confirmed the favorable effect of lidocaine in mitigating hemodynamic changes [3, 23, 24]. Although intravenous injection of lidocaine rapidly affects hemodynamic changes, its spray was used in the present study due to complications related to the central nervous system and cardiovascular system [18].

Conclusion

The findings of the present study indicate that magnesium sulfate spray is more effective than lidocaine in controlling hemodynamic complications. However, it may be associated with tachycardia, which should be taken into consideration.

Limitations

The present study has several limitations, including the relatively small number of patients studied, the absence of a control group with no intervention, and the lack of examining some variables, such as mean arterial pressure in these patients.

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Author contributions

MKh and BM designed and reviewed the study materials. BM prepared the ethics submission. MB, MR, and FB critically reviewed the manuscript. MR and FB oversaw all aspects of the study's implementation. All authors read and approved the final manuscript.

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Data availability

The datasets generated and/or analysed during the current study are not publicly available [due to confidentiality concerns] but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This article was approved by the Ethics Committee of Hamadan University of Medical Sciences under the ethics code IR.ABZUMS.REC.1402.086 and registered under IRCT20230719058846N1 on 31/10/2023 in the Iranian Registry of Clinical Trials. All methods performed by the declaration of Helsinki. After explaining the research objectives, we obtained written informed consent from all participants and informed them about the confidentiality of the data.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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