



Can intussusceptions of small bowel and colon be transient? A prospective study

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Abstract

We performed a prospective study to explore a diagnosis and treatment protocol of transient intussusception in children (TIC). Totally, 143 children with intussusception who met the inclusion criteria were firstly divided into intussusception involving only the small bowel and intussusception involving the colon group. And in each group, they were further divided into short-segment (≤ 3.0 cm) and long-segment (> 3.0 cm) groups according to the length of intussusception. After a period of conservative treatment, the incidence of TIC, the incidence of surgery, and recurrence were collected and analyzed. Finally, we found that the incidence of TIC in the short-segment group of small bowel intussusception (96.29%) was significantly higher than that in other groups ($P \leq 0.001$). Besides, the incidence of surgery and recurrence in this group was relatively low too. Therefore, we summarized the inclusion criteria and treatments to the short-segment group of small bowel intussusception as the suggested protocol to TIC.

Conclusion: For cases of small bowel intussusception with no identified pathologic lead point, a short duration of symptoms, a length of ≤ 3.0 cm, a relatively abundant vascular flow signal, and a stable general condition, the spontaneous reduction could be expected and a period of conservative treatment with careful monitoring is recommended.

What is Known:

- The phenomenon of spontaneous reduction in intussusception (transient intussusception) among pediatric patients has been widely reported.
- To distinguish the transient intussusception from the other types is important for the transient ones only need conservative treatment rather than enema reduction or surgery.

What is New:

- This is the first prospective study to explore a diagnosis and treatment protocol of transient intussusception in children.
- Short-segment small bowel intussusceptions have a higher rate (96.29%) to get spontaneous reduction than the other types of intussusception.

Keywords Children · Intussusception · Transient intussusception · Spontaneous reduction · Ultrasound

Abbreviations

CDI Color Doppler image
DOS Duration of symptoms

PLP Pathological lead point
TIC Transient intussusception in children
US Ultrasound

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Introduction

Intussusception, defined as the invagination of one part of the intestine into another, is one of the most common abdominal emergencies in early childhood [1]. Both the small bowel and colon can be involved. According to the etiology, intussusception can be mainly divided into two kinds: idiopathic and secondary to a pathological lead point (PLP). Of these two, idiopathic is by far more frequent at approximately 90% of all cases of intussusception [2].

In 1940, Goldman and Elman [3] reported on four children with transient intussusception in which the phenomenon of spontaneous reduction was witnessed. Since then, several studies have reported this kind of transient intussusception in children (TIC), which is self-limited and can reduce spontaneously without any special intervention [4–14]. And with the wider availability and better resolution of ultrasound (US), an increasing number of TIC have been reported. Therefore, intussusception could also be further classified into two general types: fixed intussusceptions, which are mostly symptomatic and require treatment; transient intussusceptions, which are mostly asymptomatic and are assumed to reduce spontaneously [1]. Although these transient intussusceptions were mostly reported to involve only the small bowel, transient intussusceptions involving the colon have also been reported [1, 4–14].

As to the treatment of intussusceptions, reduction by hydrostatic or air enema is the preferred treatment to the intussusceptions involving the colon. But in the treatment of intussusceptions involving only the small bowels, because the liquid or air from an enema may not reach the site of intussusception, leading to a low successful rate of enema reduction, surgical exploration becomes the main treatment. However, whether enema or surgery, it is risky. Enema may cause intestinal perforation and air enema may cause radiation exposure risks, while surgery may cause complications to patients and increase medical expenses. Therefore, it is very necessary to distinguish the transient intussusceptions (which only need conservative treatments) from the others (which need further treatment), to avoid the risks of enema reduction and surgical exploration.

By reviewing the records of children with transient intussusception, Kornecki et al. [4] recommended that when a short-segment intussusception with no PLP is spotted, particularly in an asymptomatic patient, conservative observation is warranted. Additionally, Kim [7] has summarized the typical US features of transient small bowel intussusception as follows: (1) a small outer diameter (less than 2.5 cm), (2) short-segment (less than 3 cm), (3) preserved intestinal wall motion, and (4) absence of PLP. Furthermore, Mateen et al. [8] and Guney et al. [13] have also confirmed the similar features of transient small bowel intussusception, but the length of segment was reported to

be less than 3.5 cm and less than 2.3 cm, respectively. However, almost all of these studies are retrospective ones and there has been a lack of prospective studies using these findings to distinguish the TIC from other kinds of intussusception in clinical practice.

Therefore, according to the reported characteristics, we performed this study to explore a diagnosis and management protocol of TIC to distinguish it from other intussusceptions and then to prospectively verify the protocol's clinical practicability.

Methods

This prospective study was approved by the Institutional Review Board and Ethical Committee at the West China Hospital of Sichuan University in China (No.407, November 10, 2015). All procedures followed the research protocols approved by Sichuan University and the West China Hospital of Sichuan University and were conducted according to the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Written informed consent for participation in this study was provided, and the use of clinical records was approved by the patients' parents or the person with parental authority.

Candidates for inclusion in this study were pediatric patients (from birth to 18 years old) who were diagnosed with intussusception in the emergency department of West China Hospital of Sichuan University in China from January 2016 to December 2017. The diagnosis and identification of the site of intussusception were determined by experienced US examiners through ultrasonography according to its typical appearance as described previously [15–17].

Once considering that “the duration of symptoms > 48 h” was the risk factor for the recurrence of intussusception and the failure of enema reduction [18, 19], we set “the duration of symptoms (DOS) \leq 42 h” as the first inclusion criteria to make sure that after a period of conservative treatment (for no more than 6 h) described below, the DOS in all the included patients was no more than 48 h in total. Therefore, the complete inclusion criteria were set as follows: (1) the DOS \leq 42 h; (2) the absence of PLP (including Meckel's diverticulum, intestinal polyps, and duplications); (3) the peristalsis or the existence of vascular flow signal in the intussusception suggested by color Doppler image (CDI); (4) the stability of vital signs in the patients, with no signs of peritonitis, perforation, or hemodynamic instability despite adequate resuscitation [4–8, 10–13]. The rest of the patients with intussusception were treated with surgical or enema reduction as soon as possible.

Depending on the pathology, treatment plan, and anatomical location, we first divided the intussusception patients who met the inclusion criteria into intussusception of the small bowel (involving only the small bowel) group and intussusception of the colon (involving the colon) group. Then in each intussusception group, according to the length of intussusception, we further divided them into the short-segment group (in which the length of intussusception was ≤ 3.0 cm) and the long-segment group (in which the length of intussusception was > 3.0 cm) [4, 5, 7–13]. All patients were treated conservative at first according to protocol. As mentioned before, according to Kornecki et al. [4] and Kim [7], the majority of the spontaneous reduction of intussusceptions occurred within 6 h. In light of this, we set the conservative treatment period as no more than 6 h from the patients' arrival at the emergency department. The conservative treatment included the following: (1) fasting and water deprivation, a nasogastric tube would be inserted if the patient suffered from recurrent vomiting; (2) intravenous fluid resuscitation would be initiated; (3) the abdominal US would be repeated every 1–2 h for evaluation until the spontaneous reduction was confirmed [1, 4–9, 11].

The conservative treatment would be suspended and converted to surgery or enema reduction immediately if any of the following conditions occurred: (1) general deterioration (including worsening abdominal pain or distension and worsening rectal bleeding), the signs of peritonitis, perforation, or hemodynamic instability in spite of adequate resuscitation; (2) increase in the length of intussusception by more than 1 cm; (3) rapid deterioration or disappearance of the vascular flow signal in the intussusception suggested by CDI; (4) the continuing existence of intussusception after 6 h of conservative treatment [7–13].

All the patients included were observed in the emergency department initially, except for patients who need surgical treatment.

We considered the inclusion criteria and the treatment protocol of the short-segment group as the diagnosis and management protocol of TIC.

Primary and secondary outcome

The primary outcome of the study was the incidence of spontaneous reduction within the 6 h of conservative treatment. The secondary outcomes of this study were the number of surgical reduction, number of patients with bowel perforation, number of bowel resection, and number of patients with recurrent intussusception.

Statistical analysis

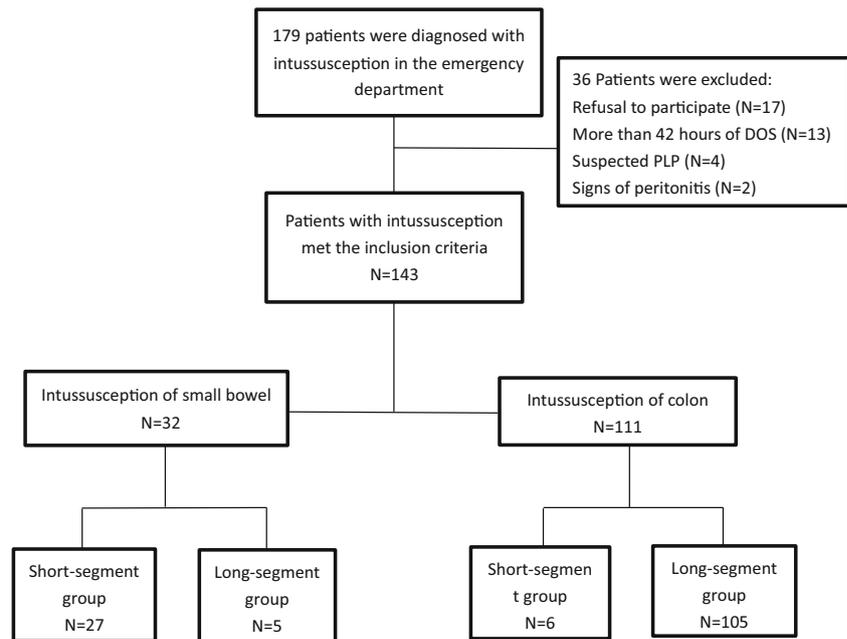
Statistical analysis was performed using SPSS Statistics for Windows (version 23.0). The categorical descriptive data

were presented as number (N) and percentage (%) and were analyzed with the χ^2 test or Fisher's exact test. The numerical descriptive data were presented as mean and standard deviation (SD) and were analyzed with the t test or Mann-Whitney U test. A P value < 0.05 was considered statistically significant.

Results

A total of 179 pediatric patients with intussusception were identified in the emergency department of West China Hospital of Sichuan University from January 2016 to December 2017 (Fig. 1). The follow-up duration was at least 6 months. Among them, 36 patients were excluded from the study due to the following reasons: their refusal to participate ($n = 17$), more than 42 h of DOS ($n = 13$), suspected PLP ($n = 4$), and signs of peritonitis ($n = 2$). The remaining 143 patients were enrolled in this study and were firstly divided into the intussusception of the small bowel group ($n = 32$) and intussusception of the colon group ($n = 111$). Then, they were further divided into short-segment and long-segment in each group. The baseline characteristics were summarized in Table 1. The male to female ratio was 1.8:1. The median age of the patients was 22 months and the mean weight was 12.49 kg. The most common symptoms were abdominal pain (86.01%), vomiting (76.92%), and rectal bleeding (23.08%). Diarrhea (6.99%), distention (5.59%), and constipation (5.59%) were also recorded. About 18.88% of the patients had temperature higher than 37.4 °C. The palpable mass was identified in 42.66% of them and was more common in the long-segment group ($P = 0.001$). The median DOS was 23 h. The rate of intussusception of the small bowel and intussusception of the colon was different between the short-segment group and long-segment group ($P < 0.001$). The mean length of intussusception was 40.65 mm.

The outcomes of the patients were shown in Table 2. In 32 patients (22.38% of total), the intussusceptions were spontaneously resolved within 6 h after conservative treatment. And 30 of these spontaneous reductions occurred within 4 h after the conservative treatment. The incidence of TIC was significantly higher in the short-segment group of small bowel intussusception (96.29%) than that in the long-segment group of small bowel intussusception (20%, $P = 0.001$). Moreover, it was also higher than that in the short-segment group (16.67%, $P < 0.001$) and long-segment group (3.81%, $P < 0.001$) of the intussusception involving the colon. However, there was no significant difference in the incidence in TIC between the short-segment and long-segment groups of intussusception of the colon ($P = 0.247$). In addition, the incidence of TIC in intussusception of the small bowel (27/32) was significantly higher than that in intussusception of the colon (5/111) ($P < 0.001$).

Fig. 1 Study flow of the patients diagnosed with intussusception

The rate of surgical reduction between the short-segment and long-segment groups was statistically significant in the intussusception of the small bowel ($P = 0.001$), but not in the intussusception of the colon ($P = 1.000$). In the end, six

Table 1 Baseline characteristics of the included patients

Characteristics	All, <i>n</i> (%) <i>N</i> = 143	Short-segment group, <i>n</i> (%) <i>N</i> = 33	Long-segment group, <i>n</i> (%) <i>N</i> = 110	<i>P</i> value
Sex				
Male	92 (64.34)	23 (69.70)	69 (62.73)	0.538
Female	51 (35.66)	10 (30.30)	41 (37.27)	
Age (month) ^a	22 (10–36)	22 (8–37)	22 (12–32.75)	0.948
Weight (kg) ^b	12.49 (4.09)	13.11 (4.39)	12.30 (3.99)	0.446
Symptoms				
Vomiting	110 (76.92)	26 (78.79)	84 (76.36)	0.819
Abdominal pain	123 (86.01)	28 (84.85)	95 (86.36)	1.000
DOS (hour) ^a	23 (15–29)	20 (13–32)	23 (16–29)	0.969
Rectal bleeding	33 (23.08)	5 (15.15)	28 (25.45)	0.249
Distension	8 (5.59)	3 (9.09)	5 (4.55)	0.572
Diarrhea	10 (6.99)	4 (12.12)	6 (5.45)	0.353
Constipation	8 (5.59)	0 (0.00)	8 (7.27)	0.245
Signs				
Temperature (°C) ^b	37.08 (0.47)	37.13 (0.53)	37.06 (0.45)	0.664
Palpable mass	61 (42.66)	6 (18.18)	55 (50.00)	0.001
Type of intussusception				
Intussusception of the small bowel	32 (22.38)	27 (81.82)	5 (4.55)	< 0.001
Intussusception of the colon	111 (77.62)	6 (18.18)	105 (95.45)	
Length of intussusception (mm) ^b	40.65 (15.49)	22.94 (4.77)	45.96 (13.50)	

P value is the contrast between the short-segment group and long-segment group

DOS duration of symptoms

^a Median, interquartile range

^b Mean, standard deviation

Table 2 Outcomes of the included patients

Outcomes	All, <i>n</i> (%)	Intussusception of the small bowel, <i>n</i> (%)		<i>P</i> value	Intussusception of the colon, <i>n</i> (%)		<i>P</i> value
		Short-segment group (<i>n</i> = 27)	Long-segment group (<i>n</i> = 5)		Short-segment group (<i>n</i> = 6)	Long-segment group (<i>n</i> = 105)	
Spontaneous reduction	32 (22.38)	26 (96.29)	1 (20.00)	0.001	1 (16.67)	4 (3.81)	0.247
Enema reduction	105 (73.43)	0 (0.00)	0 (0.00)		5 (83.33)	100 (95.24)	
Surgical reduction	6 (4.19)	1 (3.70)	4 (80.00)	0.001	0 (0.00)	1 (0.95)	1.000
The method of operation							
Simple reduction	5 (3.49)	1 (3.70)	4 (80.00)		0 (0.00)	0 (0.00)	
Bowel resection and anastomosis	1 (0.69)	0 (0.00)	0 (0.00)		0 (0.00)	1 (0.95)	
Recurrence	11 (7.69)	1 (3.70)	0 (0.00)	1.000	2 (33.33)	8 (7.62)	0.09

P value is the contrast between the short-segment group and long-segment group

patients underwent surgical reduction. Among them, one 20-month-old girl's small bowel intussusception continued after the 6 h of conservative treatment. So, a surgical exploration was performed, but no intussusception or PLP was found during the operation, and it indicated that the intussusception had resolved itself prior to the surgery. Nevertheless, we did not count this case as TIC in our study. One patient with intussusception of the colon in the long-segment group underwent bowel resection and anastomosis due to Meckel's diverticulum. Finally, all the 6 patients recovered and were discharged eventually. No perforation occurred during this study.

Whether in the intussusception of the small bowel or in the intussusception of the colon, there was no statistical difference in the rate of intussusception recurrence between the short-segment and long-segment groups ($P > 0.05$). Notably, 1 patient with recurrent small bowel intussusception and 1 patient with recurrent ileocolic intussusception were treated conservatively and got spontaneous reduction again just as they had before in the short-segment group. And the remaining 9 patients with recurrent intussusception were eventually discharged after successful enema reduction.

For intussusceptions that failed to get spontaneous reduction, the enema reduction was preferred for the intussusception of the colon, and surgery was performed as soon as possible for the patients with an unsuccessful enema reduction or with intussusception of the small bowel. The main conditions which lead to the suspension of conservative treatment are shown in Table 3. "Increase in the length of intussusception by more than 1 cm" was the most common condition leading to the suspension. For 2 patients, whose vascular flow signal in intussusception rapidly deteriorated or disappeared, successful enema reduction was achieved using a relatively low pressure. As for etiology, almost all of the cases were idiopathic (over 99%) except for the one case with Meckel's diverticulum. We also compared the DOS of the intussusceptions that were resolved spontaneously within 6 h ($n = 32$) with the intussusceptions which were not ($n = 111$), and the

results showed no significant difference between them ($P = 0.779$). All of the 111 patients were discharged eventually after surgical or enema reduction.

In this study, there were 39 patients less than 1 year of age. Among them, intussusceptions in 13 patients had spontaneous reduction within 6 h. For the remaining 26 patients, the most common condition leading to the suspension of conservative treatment was still the increase of length. The rate of patients suffering general deterioration in the infants < 1 year of age showed no statistical difference with that in the infants ≥ 1 year of age ($P = 0.743$). In the end, all the patients less than 1 year of age were eventually discharged.

Discussion

With the widespread use of US and its increased resolution, a larger number of patients with transient intussusception have been detected [4, 6–14]. The rate of spontaneous reduction of intussusceptions has been reported to be as many as 17–38% of all cases of intussusception [4, 6, 8, 13]. In our study, the total rate of TIC was familiar to the reported ones as 22.38%. As to the anatomical type of TIC, although most of them were reported as small bowel intussusceptions, it has also been reported that the rate of transient intussusception in the colon was up to 14% among all TIC [1, 4]. This is why we also included the intussusception of the colon in this study. Finally, the results of this study confirmed that the majority of TIC were small bowel intussusception (84.38%), and the rate of them was significantly higher than that in the intussusception of the colon (4.5%) ($P < 0.001$). Additionally, the incidence of TIC in the short-segment group of small bowel intussusception (96.29%) was significantly higher than that in the other groups ($P \leq 0.001$). Therefore, we summarized the inclusion criteria and treatment protocol to the short-segment group of small bowel intussusception as the suggested diagnosis and management protocol to TIC (Fig. 2).

Table 3 Analysis of the cases that failed to get spontaneous reduction within 6 h ($n = 111$)

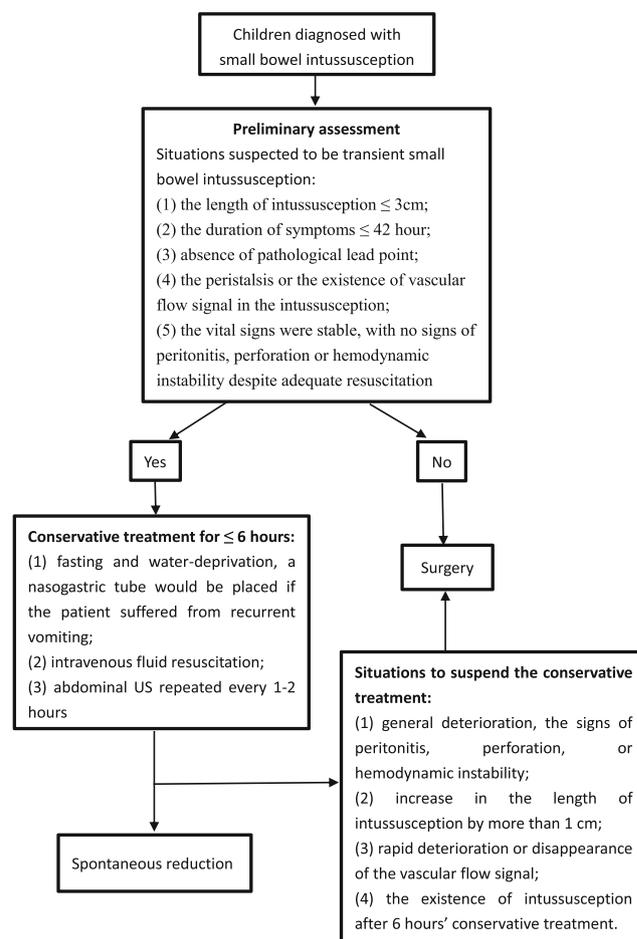
	Intussusception of the small bowel, n (%)		Intussusception of the colon, n (%)	
	Short-segment group ($n = 1$)	Long-segment group ($n = 4$)	Short-segment group ($n = 5$)	Long-segment group ($n = 101$)
Main conditions				
General deterioration (including hemodynamically unstable, worsening abdominal pain or distension, worsening rectal bleeding)	0 (0.00)	1 (25.00)	1 (20.00)	30 (29.70)
Increase in the length of intussusception by more than 1 cm	0 (0.00)	2 (50.00)	3 (60.00)	41 (40.59)
Rapid deterioration or disappearance of vascular flow signal	0 (0.00)	0 (0.00)	0 (0.00)	2 (1.98)
The existence of intussusception after 6 h of conservative treatment	1 (100.00)	1 (25.00)	1 (20.00)	28 (27.72)
Etiology				
Idiopathic	1 (100.00)	4 (100.00)	5 (100.00)	100 (99.00)
Meckel's diverticulum	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.99)

Considering the relatively low incidence of TIC and the insignificant statistical results between the short-segment and long-segment groups in intussusception of the colon in our study, we do not recommend this protocol for the management of intussusception of the colon.

In this study, 93.75% (30/32) of TIC were resolved spontaneously within 4 h, which were similar to the previous study [4, 7–9, 11]. It is worth noting that among the patients who underwent surgical reduction, no intussusception was found during the operation in a 20-month-old girl from the short-segment small bowel intussusception group. We speculated that it might be a delayed spontaneous reduction of intussusception that occurred after 6 h of conservative treatment. This may indicate that we could extend the observation time appropriately, but the risk of delayed treatment may also increase over time. Hence, the ideal time point which could balance the benefits and risks of long observation is still worth discussing.

Except the characteristics of TIC mentioned in the introduction, Zhang et al. [11] also found that the length of intussusception ≥ 4.2 cm was an index with high sensitivity and specificity of the need for surgical management in small bowel intussusception. Munden et al. [9] also suggested that the length of intussusception greater than 3.5 cm was a strong independent predictor of the need for surgical intervention. Therefore, according to the studies mentioned above and considering the race factor, we set “the length of intussusception ≤ 3.0 cm” and “the existence of vascular flow signal in the intussusception” as part of the criteria for suspected cases of TIC. Afterwards, the “increase in the length of intussusception by more than 1 cm” and “rapid deterioration or disappearance of vascular flow signal” were set as the indicators to convert the conservative treatment to surgical or enema reduction. These two indicators may indicate the progress of the disease, thus avoiding the deterioration of general condition of the

patient or the occurrence of intestinal necrosis. In this study, we strictly followed the conditions for suspending the conservative treatment, and no perforation or intestinal necrosis occurred.

**Fig. 2** Diagnosis and management protocol to the children with suspicion of transient small bowel intussusception in our center

There are several limitations in our study. Firstly, all the protocols were conducted in one institution and the number of patients was limited. Secondly, we could not exclude the possibility that there might be some unrecognized PLP in some patients. However, after at least 6 months of follow-up, none of these patients has frequently recurrent intussusception or needs to have abdominal exploration surgery so far; therefore, the possibility seems to be relatively low. Finally, US is an operator-dependent examination; there could always be some degrees of error in the length measurement of intussusception.

Conclusion

In conclusion, for the cases of small bowel intussusception in children with no identified pathological lead point, a short duration of symptoms (≤ 42 h), a length of ≤ 3.0 cm, a relatively abundant vascular flow signal, and a stable general condition, the spontaneous reduction can be expected to occur and a period (≤ 6 h) of conservative treatment with careful monitoring is recommended. However, this protocol is not recommended for the treatment of intussusception involving the colon, and future evidence of effective application in larger series of patients is needed before widespread acceptance and use of this protocol.

Authors' contributions Qi Wang: participated in the design of this study, acquired and analyzed the data, drafted this manuscript, and agreed on the final version of this manuscript.

Mengqi Luo: participated in the design of this study, run statistical analysis of the data, drafted this manuscript, and agreed on the final version of this manuscript.

Xiaolong Xie: participated in the design of this study and agreed on the final version of this manuscript.

Yang Wu: designed this study, critically revised this manuscript, and agreed on the final version of this manuscript.

Bo Xiang: designed this study, critically revised this manuscript, and agreed on the final version of this manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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