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CASE REPORT

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Ultrasound-guided femoral nerve block combined with lateral femoral cutaneous nerve block in a patient with congenital insensitivity to pain and anhidrosis: a case report

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Abstract

Congenital insensitivity to pain with anhidrosis (CIPA), also known as hereditary sensory and autonomic neuropathies (HSAN I-V), is an exceptionally rare autosomal recessive disorder. The pathogenesis of CIPA remains not fully elucidated. Clinical manifestations primarily include the absence of pain perception, painless injuries to the extremities, oral mutilation, anhidrosis accompanied by hyperthermia, and delayed intellectual development. Given the autonomic dysfunction in CIPA patients, previous reports on anesthetic management for this rare disorder have predominantly depended on general anesthesia or neuraxial anesthesia, both of which pose significant challenges. This case report presents a unique approach to anesthetic management in a child with CIPA, who successfully underwent hollow nail internal fixation for femoral neck fracture under orthopedic navigation using ultrasound-guided femoral nerve block combined with lateral femoral cutaneous nerve block. The patient was sedated with dexmedetomidine and did not require any opioids during the procedure. Her vital signs remained stable throughout the surgery, and her recovery was uneventful, with discharge occurring 5 days post-operation. This case contributes to the medical literature by demonstrating a safe and effective anesthetic strategy in a pediatric CIPA patient, highlighting the potential of regional anesthesia techniques as a viable alternative to general anesthesia or neuraxial anesthesia in such high-risk cases.

Keywords Nerve block, Hereditary sensory and autonomic neuropathies, Autonomic nervous system diseases, Femoral neck fractures

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Background

Congenital insensitivity to pain with anhidrosis (CIPA) is a rare autosomal recessive disorder, with an estimated prevalence of 1 in 125 million [1]. It is primarily caused by mutations in the neurotrophic tyrosine kinase receptor 1 (NTRK1) gene [2], which disrupt the function of the tyrosine kinase receptor for nerve growth factor (TRKA-NGF). This dysfunction impairs pain and temperature perception, as well as sweat gland activity [2]. Clinically, CIPA manifests as pain insensitivity, anhidrosis, recurring fevers, self-mutilation, infections, and intellectual developmental delay [3]. The inability to feel pain leads to undiagnosed injuries, while the lack of sweating causes thermoregulation issues, increasing the risk of hyperthermia.

These distinctive features pose significant challenges for anesthetic management in CIPA patients. Autonomic dysfunction—manifesting as bradycardia, thermoregulatory instability, and gastroesophageal reflux—complicates anesthesia, increasing the risk of aspiration and other complications during general anesthesia [4]. Despite some reports using general or neuraxial anesthesia, these methods remain risky due to autonomic instability and hemodynamic variability. In fact, reports on CIPA patients undergoing general anesthesia or neuraxial anesthesia often note complications such as aspiration or hemodynamic instability, even with standard preparation [4, 5].

This case report describes the anesthetic management of a child with CIPA undergoing hollow nail internal fixation for a femoral neck fracture. Given the patient's unique physiological challenges, we used ultrasound-guided femoral nerve block and lateral femoral cutaneous nerve block to avoid the risks associated with general anesthesia or neuraxial anesthesia.

Case presentation

An 11-year-old girl (weighing 30 kg and 140 cm tall) was admitted to our hospital following a fall that resulted in a femoral neck fracture. This child was diagnosed with CIPA with HSA type V at the age of three, and her genetic testing identified a mutation in the NTRK1 gene. Preoperatively, following a comprehensive physical examination by an anesthesiologist, Her lower limbs exhibited multiple skin scars due to injuries and burns (Fig. 1), and her nails showed deformities with ulcerations (Fig. 2). Her airway assessment was unremarkable. She presented with a 3 cm shortening of her left lower limb and a positive Trendelenburg sign. The X-ray reported a fracture of the left femoral neck. Her intellectual development was unaffected, allowing her to communicate effectively with medical staff, and she reported no pain at the fracture region but limited mobility of the left hip. The anesthesiologist used the manual muscle testing grading system (MMT testing) (Table 1) to evaluate the quadriceps muscle strength of both lower limbs and found that it was grade 2 on the left and grade 5 on the right. She had been febrile since admission, with temperatures ranging from 38.2 to 38.7℃ and presenting dry skin without perspiration. Her other laboratory examinations were normal, as was a physical examination of her cardiovascular and pulmonary systems. The risks and benefits of general anesthesia, neuraxial anesthesia and peripheral nerve block were discussed. Although her parents were advised that peripheral nerve block had not been described for orthopedic surgery in a child with CIPA, they chose to proceed with this method.

In the operating room, the patient's blood pressure, electrocardiogram, pulse oximetry, and bispectral index (BIS), and tympanic temperature were monitored and sedated with intravenous midazolam 2 mg. We used the infrared tympanic–Braun Thermoscan (Braun GmbH, Kronberg, Germany) to measure the tympanic temperature of the patients [6], as they have the same blood supply as the hypothalamus in the brain's temperature control center [7]. Therefore, the tympanic temperature can accurately reflect the core body temperature both before and after anesthesia. She was placed in supine position, and the inguinal skin was disinfected using iodophor. A high-frequency linear transducer was positioned parallel and perpendicular to the inguinal ligament, and the transducer was gently moved to the inner 1/3 of the line between the anterior superior iliac spine and the pubic tubercle. Under sonographic visualization, the femoral nerve appeared as a hyperechoic, honeycomb-like structure lateral to the femoral artery (Fig. 3). Careful observation of the structure and morphology of the her femoral nerve under ultrasound did not reveal any abnormality. Subsequently, using the in-plane approach technique, a 22G needle was advanced from lateral to medial, approaching the femoral nerve. Following negative aspiration, and 10 mL of 0.5% ropivacaine was administered near the femoral nerve. The transducer was slightly moved laterally in the inguinal region, and the sonograms showed the anterior superior iliac spine, the anterior inferior iliac spine, and the iliopsoas muscle. Using the in-plane approach technique, the 22G puncture needle was advanced from medial to lateral aspect of the anterior superior iliac spine and the superficial layer of the iliopsoas muscle. After negative aspiration,5 mL of 0.5% ropivacaine was injected to block the lateral femoral cutaneous nerve. We observed that without local anaesthesia, the patient expressed no discomfort when the 22G needle was inserted into her skin or during the entire puncture procedure. Twenty minutes post-nerve block, the anesthesiologist used a blunt needle to lightly stimulate her fracture region, which did not elicit a pain response. Subsequently, when stimulating

Fig. 1 The CIPA patient's lower limbs exhibited multiple skin scars due to injuries and burns

the contralateral lower limb, the child reported that she felt only differential pressure. However, when we used the MMT testing to evaluate her quadriceps muscle strength of both lower limbs and found that it was grade 0 on the left and grade 5 on the right. Compared with the preoperative MMT testing results, it indicates that the nerve block has a motor blocking effect on the femoral nerve of the affected limb.

Continuous intravenous infusion of dexmedetomidine (0.1 μg/kg/hr) was administered to maintain BIS between 60 and 80. Intraoperatively, the patient's blood pressure, heart rate, BIS, and tympanic temperature were closely measured every 5 min (Fig. 4). The procedure used orthopaedic navigation for precise localization, drilling of Kirschner wires as guides, and placement of two 7.3 mm semi-threaded screws to complete fracture fixation. During the skin incision, Kirschner wire insertion, and screw insertion, the patient was awakened for evaluation for pain or discomfort, and adverse reactions were recorded. The surgery lasted 2 h, during which no opioids were administered. The patient's intraoperative tympanic temperature was maintained between 36.5–37.0℃, blood pressure was 87–104/41–61 mmHg, respiratory rate ranged from 13 to 17 breaths per minute, and heart rate fluctuated between 84 and 96 beats per minute. Patient was transferred to the ward when the Modified Aldrete score was ≥9 in the post anesthesia care unit (PACU). On the first day of postoperative follow-up, the patient's body temperature ranged from 38.3 to 38.8 ℃, and the affected limb had normal postoperative mobility (the MMT testing: grade 5). The pain was evaluated using the COMFORT-Behavior scale (CBS), and the Parents' Postoperative Pain Measure (PPPM) [8], and no significant postoperative pain was noted. Postoperatively, no opioids were required. On the fifth postoperative day, the patient was discharged from the hospital following an evaluation of the X-rays, which showed a good reduction of femoral neck fracture. Her temperature was 36.9℃, and she reported no pain or other discomforts. The patient and her guardian expressed satisfaction with the anaesthetic technique applied during the surgery.

Fig. 2 The CIPA patient's nails showed deformities with ulcerations

Table 1 MMT grades manual muscle testing grades

Grades	Description
0	No visible or palpable contraction
1	Visible or palpable contraction without motion
2	Full range of motion, gravity eliminated
3	Full range of motion against gravity
4	Full range of motion against gravity, moderate resistance
5	Full range of motion against gravity, maximal resistance

Discussion

Congenital insensitivity to pain with anhidrosis (CIPA) can be classified into five distinct types of hereditary sensory and autonomic neuropathies (HSAN I-V) [9]. The child presented in this case report was diagnosed with HSAN type V, characterized by severely affected pain and temperature sensitivity, while proprioception and sensitivity to touch pressure and vibration remain intact. After considering the characteristics of the disease and the type of surgery, we performed an ultrasound-guided femoral nerve block combined with lateral femoral cutaneous nerve block and completed hollow nail internal fixation for femoral neck fracture.

The unique pathophysiology of CIPA poses significant challenges to anesthesia management due to its autonomic dysfunction.Firstly, when CIPA patients require surgical treatment, anesthesiologist will face difficulties in hemodynamic management during the perioperative period, whether they are administering general anesthesia or neuraxial anesthesia. Freemanet al. [10] indicate that mutations of the NTRK1 gene and loss of TRKA-NGF signaling also hinder the development of sympathetic adrenergic vasoconstrictor neurons, which may exacerbate the vasodilation effect after general anesthesia or neuraxial anesthesia, leading to severe hypotension during surgery.Usually, CIPA patients are able to maintain normal upright blood pressure. However, due to the lack of TRKA-NGF signaling transduction in CIPA patients, it will also affect the development of sympathetic adrenergic neurons, resulting in low or undetectable levels of circulating norepinephrine in CIPA patients [11]. Norcliffe Kaufmannal et al. [12] showed

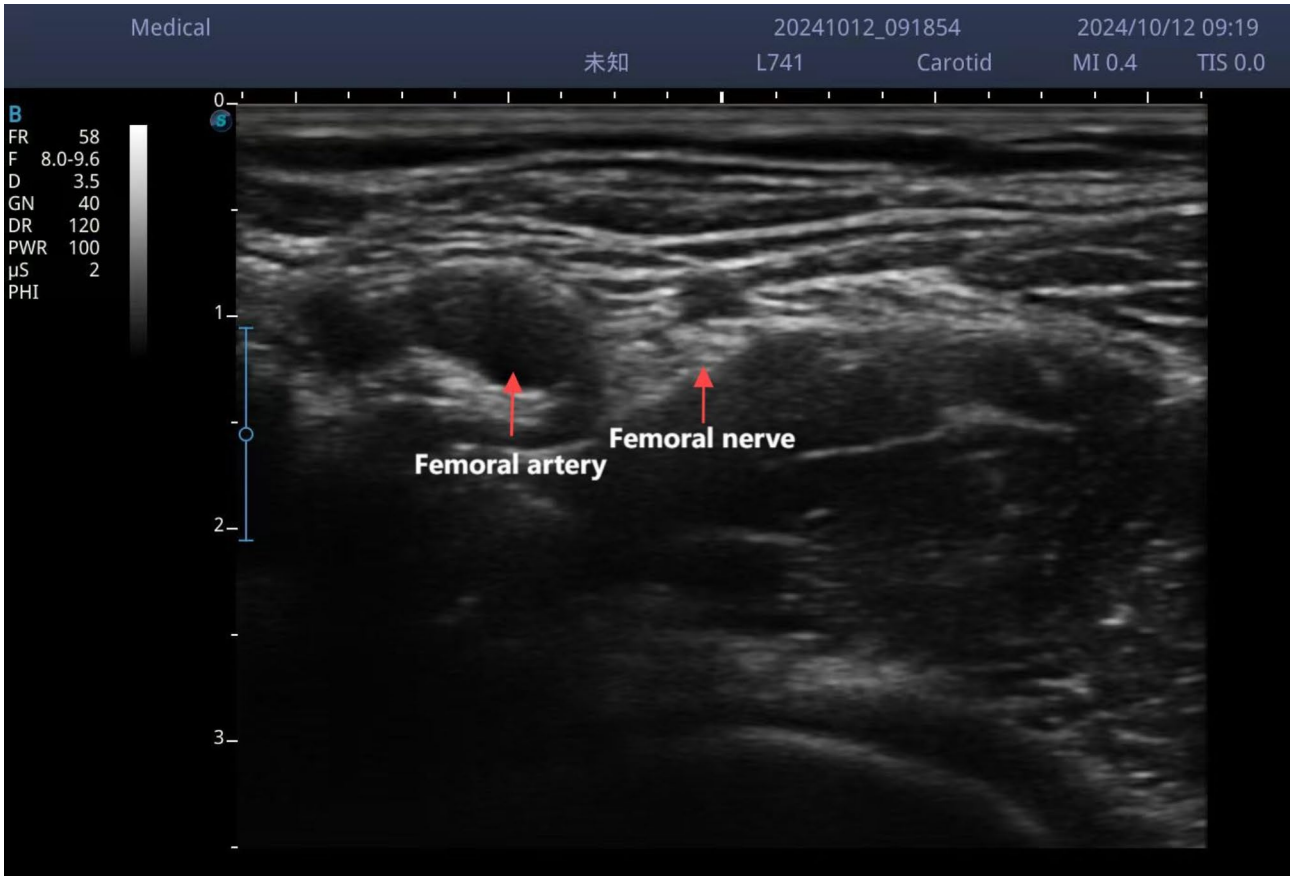

Fig. 3 Imaging of femoral nerve under sonographic visualization of the CIPA patient

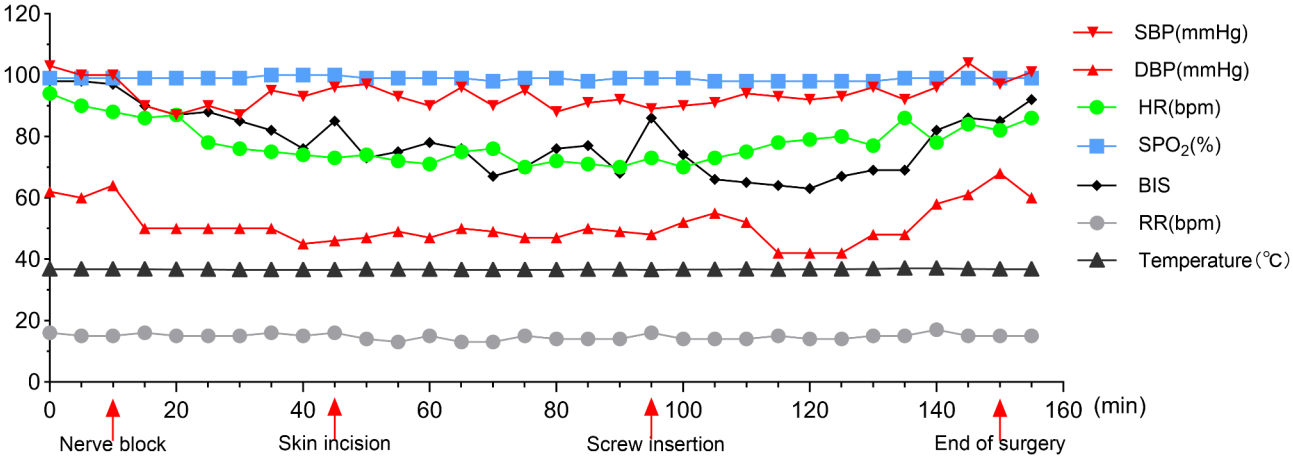

Fig. 4 Intraoperative vital signs of the CIPA patient

that the norepinephrine was undetectable in 10 of 14 patients with CIPA while in the remaining 4 only very low levels were detected (54, 40, 40 and 28 pg/ml). CIPA patients' pressor response to exogenous norepinephrine was increased suggesting denervation super-sensitivity [13]. When CIPA patients experience hypotension during surgery and receive intravenous injection of norepinephrine, it may lead to the occurrence of arrhythmia. From this, it can be seen that one of the important factors affecting the choice of anesthesia method for the autonomic dysfunction of CIPA patients is which anesthesia method can better maintain the stability of the patient's intraoperative hemodynamics. Mental retardation in CIPA can be absent or it may vary from mild to severe. Had our patient been severely mentally retarded, general anesthesia would have been preferred [11]. If CIPA

patients undergo general anesthesia, the risks of aspiration reflux and bronchospasm during the perioperative period should also be carefully considered. In a retrospective analysis of 358 CIPA patients undergoing general anesthesia, it was found that 71% of cases ($n = 254$) received propofol IV rapid anesthesia induction, and 3% of cases ($n = 12$) received rapid sequence induction with the application of cricoid pressure [14].Even if patients fast for more than 8 h, there are still reports of aspiration reflux and bronchospasm during anesthesia recovery and induction periods [14].

Although the anesthesia management guidelines of CIPA are currently limited, we believe that anesthesia methods should be selected based on the type of surgery performed on CIPA patients. In addition, besides general anesthesia and neuraxial anesthesia, it is considered inappropriate to administer sedation alone during the perioperative period for CIPA patients in clinical practice. Canbay et al. [15] thought that patients with CIPA do not require intraoperative analgesics because of their innate analgesia. However, significant tachycardia and hypertension can occur when CIPA patients without opioids undergo tracheal intubation and surgery, indicating that the stress response in CIPA patients is still present [11]. Obviously, absence of pain perception does not mean absence of stress response. One of the typical features of patients with CIPA is the loss or diminution of nociception throughout the patient's body or a large part of the body, previous studies have found that the afferents baroreceptor nerve is functional in CIPA patients, but efferent sympathetic nerves are absent [12]. This suggests that blocking the primary afferent fibers and nociceptors in CIPA patients is crucial. Based on the current body of evidence, the International Consensus on Anesthesia-Related Outcomes after Surgery (ICAROS) group recommends peripheral nerve blockade (PNB) use in hip/knee surgery for improved outcomes. PNB use is recommended for patients undergoing hip/knee surgery except when contraindications preclude their use [16]. Multiple individual randomized controlled trials (RCTs) suggest that PNB has many advantages including reduced stress responses, ensured hemodynamic stability, minimized opioids, improved patient satisfaction, better sleep patterns, improved rehabilitation, and shorter hospital stays [17]. Besides the well-established intrinsic benefits of regional anesthesia, a growing body of evidence has indicated that anesthetic technique and in particular PNB may favorably influence perioperative outcome in terms of serious complications [16]. Therefore, we believe that using nerve block in CIPA patients with femoral neck fractures is feasible and has potential advantages.

It is essential to consider individual differences and types of surgery when evaluating the potential risks and benefits of using peripheral nerve blocks in children with CIPA. In this case, the surgery performed by the CIPA patient is hollow nail internal fixation for femoral neck fracture. The surgical incision is made at a distance of 1 cm from the distal end of the anterior superior iliac spine, and a curved incision is made through the outer side of the apex of the greater trochanter, extending along the long axis of the femur. The two hollow nails are inserted above the plane of the lesser trochanter, respectively below and behind the femoral neck, with a depth of 5 mm into the subchondral bone. The dermatome involved in this procedure is primarily innervated by the femoral nerveand lateral femoral cutaneous nerve, the myotome is innervated by the femoral nerve, and the osteotome receives innervation from the obturator nerve, femoral nerve, and sciatic nerve, respectively. Theoretically, ultrasound-guided femoral nerve block combined with lateral femoral cutaneous nerve block can cover the nerve distribution for this procedure.

It is undeniable that regional blockade is not suitable for all CIPA patients with fractures. On the one hand, CIPA patients usually have infections of the skin and deep block due to exposure of internal tissues by accidental injury or self-injury, which may become a contraindication to regional block. Machtei et al. [18] investigated 33 patients with CIPA and found that 15% of patients had mandibular osteomyelitis, 70% of patients had limb osteomyelitis, and 15% of patients had both. On the other hand, there are abnormalities in the immune system of CIPA patients, such as abnormal neutrophil chemotaxis function [19] and hypogammaglobulinemia [20]. Third, when performing invasive procedures (e.g., invasive arterial blood pressure monitoring or nerve block), children with CIPA may not be able to cooperate due to their fear and anxiety. Therefore, we suggest that moderate sedation is necessary for children with CIPA implementing regional blockade and during surgery.In this case, dexmedetomidine was used as the primary sedative during the surgery for the patient. For CIPA patients using dexmedetomidine, we have the following considerations: (i) The sedative effect of dexmedetomidine in clinical use is manifested as a state similar to natural sleep, which is a "awakenable" sedative and has no significant inhibitory effect on respiratory function [21]. Compared to propofol, ketamine, etc., dexmedetomidine has the advantage of good and safe sedative effects. (ii) In the presence of autonomic dysfunction in CIPA patients, when afferent stimuli trigger the sympathetic nervous system in the absence of parasympathetic opposition resulting in excess catecholamine release throughout the body causing Paroxysmal Sympathetic Hyperactivity (PSH) [22]. When PSH is present, it triggers severe systemic symptoms such as tachycardia, hypertension, tachypnea, hyperthermia, and dystonia [22]. The published reviews support the safe and effective use of dexmedetomidine in

the treatment and prophylaxis of PSH [22]. For children with CIPA, the use of dexmedetomidine alone may be difficult to block the transmission of peripheral nociceptive stimuli during surgery, but as a sedative aid for nerve block, it can produce controllable sedative effects and prevent PSH in children with CIPA.

In addition, another difficulty in anesthesia management for CIPA patients is the evaluation of the effectiveness of neuraxial anesthesia or PNB [4]. In this case, although we cannot directly test the effect of sensory blockade on patients, MMT testing can indirectly demonstrate the effective motor blockade of their femoral nerves by local anesthetics. Meanwhile, by combining the patient's intraoperative hemodynamic parameters, the analgesic effect of nerve block can be comprehensively evaluated. Here, based on this case report, we propose several suggestions for the use of nerve block methods in CIPA patients: (i) For peripheral mixed nerve block, ultrasound-guided technology combined with nerve stimulators can be used to clarify the blocking effect on its motor function. (ii) Infrared thermography can also be used as an auxiliary method to determine the effectiveness of mixed nerve block. Regarding the relationship between peripheral nerve block and changes in peripheral skin temperature, Soriano et al. [23] showed that only when a specific nerve.

undergoes complete sensory block, changes in skin temperature in the nerve innervated area will be observed. Galvin et al. [24] confirmed that infrared thermography had higher comprehensive scores in sensitivity, specificity, and positive predictive value than cold sensation and acupuncture sensation after implementing axillary approach brachial plexus block, and proposed that infrared thermography can be used as an early and reliable evaluation basis for successful axillary nerve block.

Conclusion

This case report highlights the successful use of ultrasound-guided femoral and lateral femoral cutaneous nerve blocks in a pediatric CIPA patient undergoing femoral neck fracture surgery. This approach offers a safe alternative to general anesthesia, minimizing risks associated with autonomic dysfunction. It provides new insights into anesthetic management for CIPA patients, with benefits such as reduced opioid use and improved hemodynamic stability.

Abbreviations

CIPA	Congenital insensitivity to pain with anhidrosis
HSAN	Hereditary sensory and autonomic neuropathies
NTRK1	Neurotrophic tyrosine kinase receptor 1
TRKA	Tyrosine kinase receptor
TRKA-NGF	Tyrosine kinase receptor for nerve growth factor
MMT	Manual muscle testing
BIS	Bispectral index
PACU	Post anesthesia care unit
CBS	COMFORT-Behavior scale
PPPM	Parents' postoperative pain measure
ICAROS	International consensus on anesthesia-related outcomes after surgery
PNB	Peripheral nerve blockade
RCT	Randomized controlled trial
PSH	Paroxysmal sympathetic hyperactivity

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Author contributions

DLD and QL have contributed to the patient's anesthetic management. MMZ and AKW supervised the the process of this case. JZL and HX wrote the manuscript and LD revised the manuscript. All authors contributed to the manuscript and approved the submitted version.

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Data availability

All data related to this case report are contained within the manuscript.

Declarations

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee of Norinco General Hospital (Approval Number: 20241126113000076752).

Consent for publication

Written informed consent was obtained from the patient's guardian for publication of this case report and any accompanying images.

Competing interests

The authors declare no competing interests.

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