Inferior vena cava hemangioma resected using a novel Toumai robotic surgical platform

Ye Sunyi, MD, Zhu Yi, MD, He Anbang, MD, Peng Ding, MD, Wang Ping, MD, Xia Dan, MD, *and* Wang Shuo, MD, *Hangzhou, China*

ABSTRACT

This study aims to investigate the significance of using the Toumai robotic platform for the resection of inferior vena cava (IVC) hemangiomas. Our objective is to provide information on the potential benefits of this innovative approach in managing these uncommon vascular tumors and to contribute to the growing body of knowledge in the field of surgical oncology and vascular surgery. A 37-year-old female patient with an incidental finding of a right retroperitoneal mass underwent contrast-enhanced magnetic resonance imaging, which confirmed the diagnosis of an IVC hemangioma. Due to the rarity and complexity of this vascular tumor, the medical team opted for a novel approach using the Toumai robotic surgical platform (Shanghai MicroPort MedBot Group Co, Ltd). Under general anesthesia, the patient was placed in the left lateral decubitus position, and the robotic arms were controlled remotely through the Toumai platform. A transperitoneal approach was adopted, and the surgeon meticulously resected the tumor while preserving the integrity of the IVC. The use of the Toumai robotic platform facilitated precise tumor resection, minimizing the risk of damage to surrounding structures. The minimally invasive nature of the robotic surgery contributed to a reduced incidence of postoperative complications and accelerated patient recovery. Furthermore, the remote fifth-generation mobile network surgical capabilities of the Toumai platform allow for expert care to be provided to patients despite geographic barriers. The robotic-assisted surgical approach using the Toumai platform demonstrates its potential benefits in managing rare and complex vascular tumors such as IVC hemangiomas. Robotic technology has the potential to revolutionize the field of surgical oncology and vascular surgery, leading to improved patient outcomes and healthcare delivery. However, more extensive clinical studies and larger case series are needed to validate the long-term safety and efficacy of this innovative surgical approach. Continued research and collaboration between clinicians and robotic technology experts are essential to fully realize the potential of robotic-assisted surgery for the benefit of patients with rare and challenging medical conditions. (J Vasc Surg Cases Innov Tech 2024;10:101403.)

Keywords: Hemangioma; Inferior vena cava; Robotic surgery; Toumai surgical system

Hemangiomas, benign vascular tumors commonly found in various organs such as the liver and skin, sometimes manifest within the retroperitoneal space.[1-3] However, they rarely originate from the inferior vena cava (IVC). These vascular anomalies arising from such a critical and sizable blood vessel present unique treatment challenges and potential risks to patients.

Despite extensive research on hemangiomas in other anatomic locations, the prevalence and characteristics of IVC hemangiomas remain poorly understood. A comprehensive search of major medical databases, including Embase, Medline, and Google Scholar, yielded limited results, with only one documented case of IVC hemangioma reported in the literature. That case involved a 25-year-old male patient with a substantial 9.5-cm × 5-cm hemangioma that necessitated open surgical resection.[4]

The scarcity of reported cases highlights the rarity of IVC hemangiomas and the inherent challenges faced by surgeons in managing these infrequent vascular tumors. In the relentless pursuit of medical advancement, novel surgical techniques and cutting-edge technologies are continuously being explored to manage these complex vascular conditions. Among the promising innovations, minimally invasive robotic-assisted surgical approaches have received considerable attention due to their potential for mitigating the development of postoperative complications, facilitating shorter hospital stays, and expediting patient recovery.[5]

In the present report, we explore the significance of using the Toumai robotic platform (Shanghai MicroPort MedBot Group Co, Ltd) for the resection of IVC hemangiomas, providing information on its potential benefits in effectively managing these uncommon vascular tumors. By investigating the unique aspects of using robotic-assisted surgery for such challenging cases, we aim to contribute to the growing body of knowledge in the field

From the Department of Urology, The First Affiliated Hospital, School of Medicine, Zhejiang University.

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Correspondence: Shuo Wang, MD, Department of Urology, The First Affiliated Hospital, School of Medicine, Zhejiang University, 79 Qingchun Rd, Hangzhou, Zhejiang Province 310003, China (e-mail: shuowang11@zju.edu.cn).

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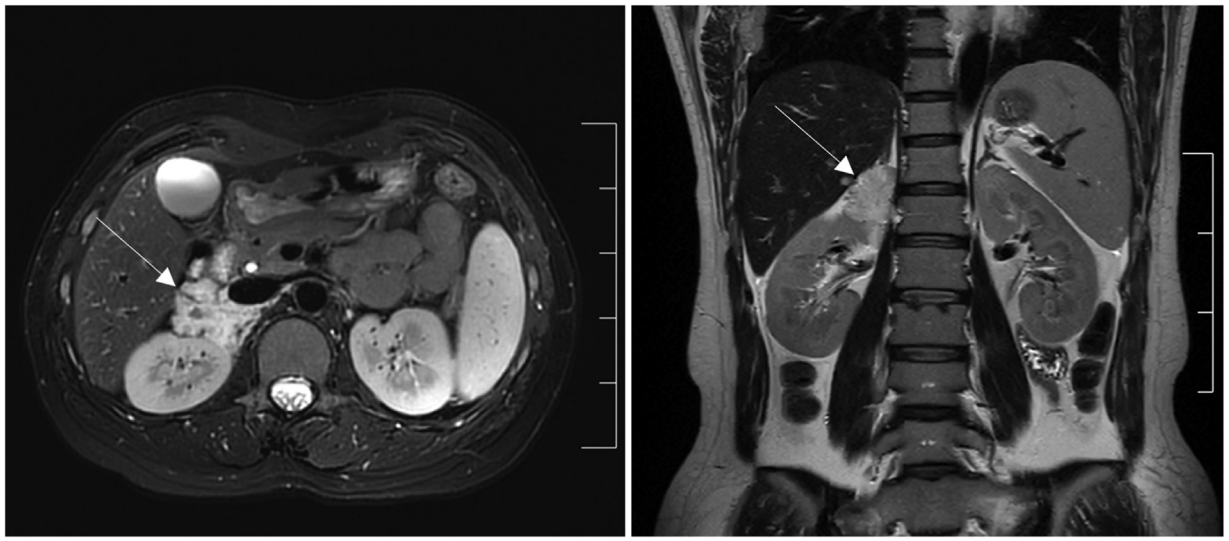

Fig 1. Magnetic resonance images of the retroperitoneal mass (*arrow*).

of surgical oncology and vascular surgery. Furthermore, we seek to highlight the advantages of this state-of-the-art platform, with potential implications for broader applications in addressing diverse medical conditions.

As the medical community continues to seek innovative solutions to improve patient outcomes, exploration of the Toumai robotic platform for resecting IVC hemangiomas promises to provide valuable insights and foster advancement in surgical precision and patient care. Continued research and clinical investigations are vital to substantiate the efficacy and safety of this novel approach, potentially transforming the landscape of vascular tumor management and providing for improved treatment options for patients with rare and complex medical conditions.

METHODS

A 37-year-old female patient presented with an incidental finding of a right retroperitoneal mass during a routine health checkup. Notably, the patient remained asymptomatic, with no reported signs or symptoms. Subsequent contrast-enhanced magnetic resonance imaging revealed an irregular patchy abnormal signal below the right adrenal gland area (Fig 1). On T1-weighted imaging, the lesion exhibited a low signal. In contrast, T2-weighted imaging showed a mixed signal. Diffusion-weighted imaging displayed a low signal. After contrast enhancement, the lesion exhibited progressive enhancement within a range of ~3.3 cm × 3.0 cm. These imaging characteristics were indicative of a retroperitoneal hemangioma. The pathology result confirmed the diagnosis. The patient provided written informed consent for the report of her case details and imaging studies.

Based on the radiologic findings, an IVC hemangioma was diagnosed. However, she was deeply concerned about the potential malignancy of the mass. Considering the rarity of this vascular tumor and its unique anatomic location, the medical team opted for a novel approach using the Toumai robotic surgical platform. The Toumai robotic system, developed in Shanghai, China (Fig 2), provides a multiple-arm platform with remote fifth-generation mobile network (5G) surgical capabilities.

Under general anesthesia, the patient was placed in the left lateral position (Fig 3, *A*) with the surgical team controlling the robotic arms (Fig 3, *B*) through the Toumai platform. A transperitoneal approach was adopted, which involving several small incisions to accommodate the robotic instruments. The robotic arms provided enhanced dexterity and a three-dimensional view of the surgical field, allowing meticulous dissection of the IVC hemangioma. The surgeon carefully resected the tumor, preserving the integrity of the IVC (Fig 4) (Supplementary Video 1). The patient had a smooth recovery and was discharged 5 days after the operation. She has had no signs of recurrence on subsequent examinations.

DISCUSSION

The present case report describes a pioneering approach to managing an IVC hemangioma through robotic-assisted surgery using the Toumai robotic platform. IVC hemangiomas are extremely rare vascular tumors, and their optimal management poses considerable challenges to surgeons. This case demonstrates the feasibility and potential benefits of using cutting-edge robotic technology in treating such complex and uncommon vascular conditions.

The rarity of IVC hemangiomas is evident from the paucity of reported cases in the medical literature. The

Fig 2. Photographs of the Tumai robot. **A,** Surgical console. **B,** Bedside robotic arm trolley. **C,** Assistant assisting in surgery at the bedside. **D,** Trocars used during surgery, including one 12-mm auxiliary port trocar, one 10-mm camera port trocar, and three 8-mm robotic arm trocars. **E,** Common instruments used during surgery, including electrocautery, bipolar forceps, needle holder, grasping forceps, and so forth. **F,** Imaging equipment cart.

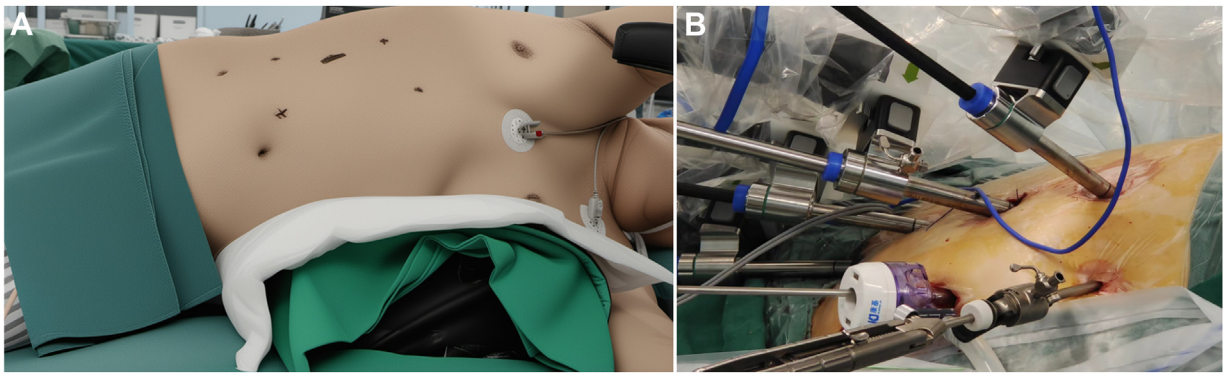

Fig 3. A, Patient in left lateral decubitus position with elevated waist. **B,** Trocars mounted with robotic arms for surgical procedures.

scarcity of data on these tumors highlights the limited understanding and experience in their management. Thus, case reports such as ours play a crucial role in expanding the knowledge base and providing information on the intricacies of treating this unusual vascular pathology.

The diagnosis of IVC hemangioma in the present case was established through comprehensive contrast-enhanced magnetic resonance imaging. The radiologic findings, highlighting an irregular patchy abnormal signal with progressive enhancement, were consistent with the typical characteristics of retroperitoneal hemangiomas. An early and accurate diagnosis is vital for determining the appropriate treatment strategy and ensuring favorable patient outcomes.

IVC hemangiomas and IVC aneurysms are distinct vascular conditions with various clinical presentations. IVC aneurysms are frequently associated with concomitant diseases, such as blue rubber bleb nevus syndrome,[6] and hemangiomas are commonly observed in individuals with Klippel-Trenaunay syndrome,[7] underscoring the diverse nature of these vascular anomalies. Additionally, solid tumors, such as leiomyosarcoma, can arise in the IVC, albeit rarely, with only a few reported cases.[8] Managing vena cava masses, irrespective of their composition, carries inherent risks, necessitating careful consideration and meticulous management in clinical practice.

Conventional open surgical resection has been the standard approach for managing vascular tumors, including those in the vena cava.[9] However, the advent of robotic-assisted surgery has revolutionized the field of surgical oncology and vascular surgery. In the present case, the Toumai robotic platform, armed with multiple-arm capabilities and remote 5G surgical functionality,

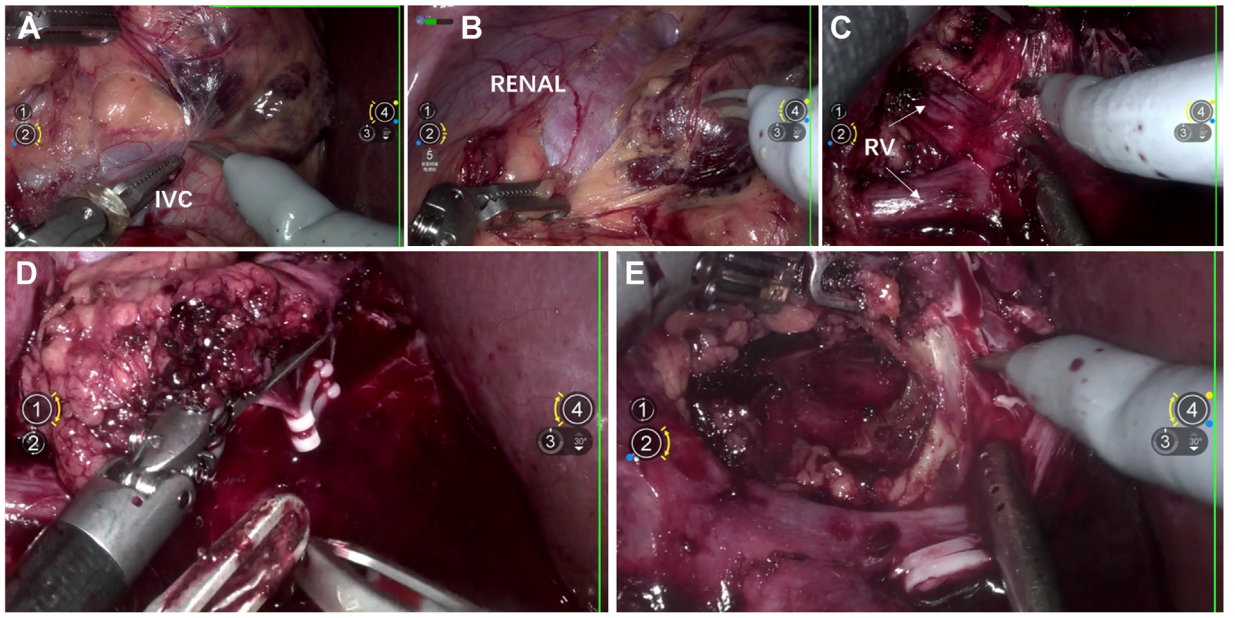

Fig 4. A, Separating the mass from the inferior vena cava (*IVC*) surface. **B,** Separating the mass from the renal surface. **C,** Freeing the mass from the renal veins. **D,** Ligating the vessel root of the mass. **E,** Dissecting the mass root from the back of the IVC. *RV,* Renal vein.

proved to be a valuable tool in achieving precise tumor resection.

Robotic-assisted surgery offers several advantages compared with traditional open surgery,[10] especially for cases involving complex anatomic locations such as the IVC. The enhanced dexterity provided by the robotic arms allows for meticulous dissection and preservation of vital vascular structures. The three-dimensional view of the surgical field aids the surgeon in navigating intricate vascular pathways, reducing the risk of inadvertent damage to nearby organs and vessels.

The minimally invasive nature of robotic surgery contributes to a reduced incidence of postoperative complications, shorter hospital stays, and faster patient recovery. These benefits are of paramount importance in managing vascular tumors, because patients could be at an increased risk of complications due to the proximity of the tumor to critical vascular structures.

Furthermore, the Toumai robotic platform's remote 5G surgical functionality adds a new dimension to surgical practice, overcoming geographic barriers and enabling expert surgeons to provide specialized care to patients in distant locations. This revolutionary technology enabled our surgical team to conduct surgeries with real-time precision ~800 km away. Ten remote surgeries have been performed, including six radical prostatectomies, one radical cystectomy, one partial nephrectomy, one radical nephrectomy, and one adrenal resection. This capability holds immense promise for improving healthcare access and bridging the gap between patients in remote areas and highly skilled surgical specialists.

However, it is essential to acknowledge that robotic-assisted surgery, although offering numerous advantages, is not without challenges. The initial setup and learning curve associated with robotic systems could prolong the surgical times during the early stages of implementation. Surgeon training and proficiency are crucial factors for optimizing outcomes and minimizing complications. The findings from this case report underscore the potential of the Toumai robotic platform in addressing rare vascular tumors such as IVC hemangiomas. Nevertheless, more extensive clinical studies and larger case series are warranted to validate the long-term safety and efficacy of this innovative surgical approach.

CONCLUSIONS

The reported case of robotic resection of an IVC hemangioma provides valuable insights into the management of these rare vascular tumors. We have demonstrated the potential benefits of the Toumai robotic platform in enhancing surgical precision, reducing the incidence of postoperative complications, and offering access to expert care regardless of geographic boundaries. As robotic technology continues to evolve, it holds immense promise in revolutionizing the field of surgical oncology and vascular surgery, ultimately improving patient outcomes and healthcare delivery. Continued research and collaboration between clinicians and robotic technology experts are essential to realize the full potential of robotic-assisted surgery for the benefit of patients with complex and uncommon medical conditions.

DISCLOSURES

None.

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