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Robot-assisted lymphovenous anastomosis surgery for lymphocele in the groin

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SUMMARY
We present the first-in-human robot-assisted microsurgery on a lymphocele in the groin involving a man in his late 60s who had been coping with the condition for 12 months. Despite numerous efforts at conservative treatment and surgical intervention, the lymphocele persisted, leading to a referral to our clinic. Diagnostic techniques, including indocyanine green lymphography and ultrasound, identified one lymphatic vessel draining into the lymphocele. The surgical intervention, conducted with the assistance of a robot and facilitated by the Symani Surgical System (Medical Microinstruments, Calci, Italy), involved a lymphovenous anastomosis and excision of the lymphocele. An end-to-end anastomosis was performed between the lymphatic and venous vessels measuring 1 mm in diameter, using an Ethilon 10-0 suture.
The surgery was successful, with no postoperative complications and a prompt recovery. The patient was discharged 3 days postoperatively and exhibited complete recovery at the 14-day follow-up. This case marks the first use of robot-assisted microsurgical lymphovenous anastomosis to address a groin lymphocele, highlighting the benefit of advanced robotic technology in complex lymphatic surgeries.

BACKGROUND
Lymphoceles, defined as an abnormal collection of lymphatic fluid lacking an epithelial lining, typically occur due to disruption of lymphatic channels, frequently as a result of surgical procedures or trauma. These conditions can lead to significant morbidity with swelling, pain and sepsis.[1] Traditional management includes conservative measures like aspiration and compression therapy to facilitate spontaneous healing or treatment with sclerotherapy or surgical intervention that involves excision of the cele and ligating the lymphatic vessel.[1] Given the potential for recurrence with ligation alone, lymphovenous anastomosis has been explored to create new, effective pathways, showing promising results.[2 3]

As the success of anastomotic patency significantly relies on the surgeon's skill and experience, robotic-assisted microsurgery could play a crucial role in enhancing the efficacy and success rates of microsurgery.[4–6] The continuous evolution and significant advancement in technology and tools have been instrumental in aiding surgeons to perform intricate procedures with enhanced efficacy.

The aim of this article is to share our insight and experience in the field of robot-assisted reconstructive lymphatic surgery, highlighting its importance in advancing patient care.

CASE PRESENTATION
The patient is a man in his late 60s with a history of rhino and renal cell carcinoma, arthritis urticaria and hypertension, for which he was receiving relevant treatments. Additionally, he experienced an oesophageal rupture related to non-steroidal anti-inflammatory drug usage in 2002 and a repaired umbilical hernia repair in 2021. He presented with a spontaneous enlargement in the right groin area that had first appeared 1 year prior.

The patient was initially seen by orthopaedic surgeons in another hospital and was diagnosed with a spontaneous lymphocele formation at the groin. Despite multiple efforts to drain the lymphocele, it repeatedly refilled. After failing to resolve the condition, the patient was referred to the vascular surgeons, who referred the patient to our clinic to find a viable treatment.

Upon evaluation in our outpatient clinic, the patient presented with a lymphocele, situated in the right groin measuring 8×7 cm in dimension, which interfered with his ability to drive his car and sit down while wearing trousers because of its size. The lymphocele was aspirated to remove 200 mL of slightly reddish, transparent fluid. This sample was analysed by pathology, which stated no abnormalities. Further examination with indocyanine green (ICG) lymphography was conducted. The ICG dye was injected intracutaneously at the first and third interdigital web spaces on the right foot and medial to the knee. This technique, which traces the uptake by lymphatic vessels, revealed the path of lymphatic vessels extending from the leg towards the groin. A lymphatic vessel extending from the knee towards the groin was clearly traceable as it emptied itself into the lymphocele.

Based on these findings, we proposed a surgical solution for the patient: anastomosing the implicated lymphatic vessel with a vein and excision of the lymphocele with detailed preoperative planning using ICG lymphography.

INVESTIGATIONS
On the day of surgery, we performed another ICG lymphography, which depicted the lymphatic vessel emptying itself into the cavity of the lymphocele (see video 1 for full ICG lymphography findings). Hereafter, we used an 18 MHz high-frequency ultrasound with its linear transducer to further examine the patient's thigh and groin. This allowed us to observe the lymphatic vessel emptying into the lymphocele once again. Additionally, we identified a nearby venous vessel, suggesting the suitability of a lymphovenous anastomosis over simply ligating

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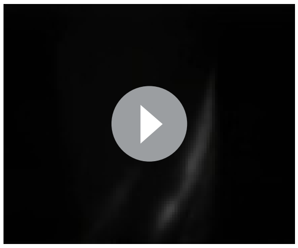


Video 1 The patient underwent indocyanine green lymphography before surgery, with the dye injected into the first and third interdigital web spaces of the foot and near the knee on the medial side. The video starts by displaying the injection sites at the foot level, gradually moving proximally towards the groin. Towards the end of the video, a circular structure becomes visible, highlighted by the indocyanine green dye; this is the patient's lymphocele. Below it, the lymphatic pathway that feeds into the lymphocele is observed.

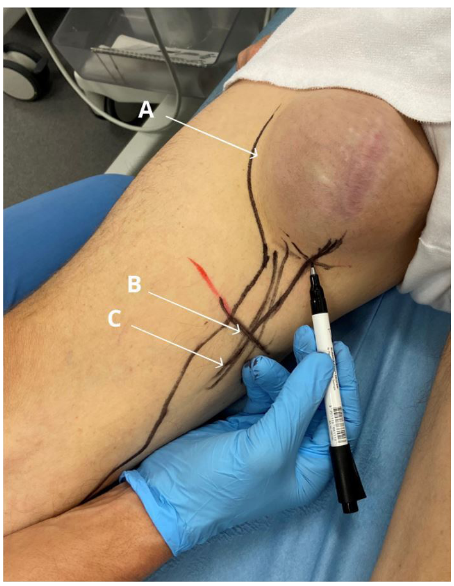


Figure 1 The patient presenting with his lymphocele in the left groin, during preoperative planning with indocyanine green lymphography and ultrasound. (A) Lymphocele, (B) the location of the subdermal vein located using ultrasound, (C) the lymph venule running towards the lymphocele, located using indocyanine green lymphography.

the lymphatic vessel (see figure 1 for an illustration of the preoperative plan). The patient agreed to undergo this procedure, which involved the excision of the lymphocele and the creation of an anastomosis between the lymphatic and venous vessels, an otherwise common procedure for the treatment of complicated lymphoceles, but with a novel twist: we planned on performing the surgery with the assistance of the Symani Surgical System (Medical Microinstruments, Calci, Italy). This advanced technique allows for greater precision and potentially improved outcomes in managing such conditions.

TREATMENT

After initial examination and preoperative planning, the patient was transferred to the operating theatre. Under general anaesthesia, the surgeons made the initial incision longitudinally over the lymphocele, penetrating the dermis to meticulously dissect the cele. The enlarged lymphatic vessel was located approximately 1.5–2 cm beneath the epidermis, with a diameter of 1 mm. A vein was closely identified, leading into the great saphenous vein. The cele was carefully separated from the adjacent tissue and entirely excised, leaving the blind end of the distal lymphatic vessel exposed.

The anastomosis was created between this lymphatic vessel and the vein using the Symani Surgical System under the microscope (see figure 2 and video 2, which present the surgeons performing robot-assisted anastomosis).

During careful and accurate movements, the venule and lymphatic vessel were freely dissected, the vein was ligated and cut proximally, followed by the application of a double-vessel clamp to secure both vessels. An end-to-end anastomosis was performed between the lymphatic vessel and venule measuring 1 mm in diameter, using an Ethilon 10-0 suture (see figure 3, which presents the anastomosis and the process of the surgery). The patency of the anastomosis was tested with ICG lymphography under the microscope and found to be functioning well (see figure 4: before closing the wound). This robot-assisted microsurgical anastomosis took a total of 34 min. Finally, a drain was placed, and the incision was closed directly using Monocryl 3-0. Prophylactic measures included a single dose of 1.5 g of Zinacef administered during surgery, and thrombosis prevention was initiated with low-molecular-weight heparin Fragmin 2500 IU before surgery, followed by an additional postoperative dosage and repeated every night until discharge and full mobilisation. The patient was encouraged to mobilise as soon as possible after surgery.

OUTCOME AND FOLLOW-UP

No signs of leakage, bleeding or haematoma formation were seen on the first postoperative day. The drain collected only a minimal volume of fluid (10 mL) and was therefore discontinued. The patient reported some pain, which was managed with 10 mg depot morphine two times per day, supplemented by additional morphine for breakthrough pain. On the third day following surgery, the patient was discharged to continue his recovery at home.

During his 14-day follow-up appointment in our outpatient clinic, the patient demonstrated complete recovery with no additional swelling of the groin and excellent healing of the surgical site (see figure 5 for postoperative results). The patient reported no pain, fever or general malaise. Although he had not resumed driving yet, he anticipated doing so in the near future. ICG lymphography was conducted again, revealing a linear pattern extending from the foot to the groin. Laterally and just below the surgical scar, the anastomosis was observed to be patent. Another significant finding was the absence of ICG accumulation in the area of the previous lymphocele, emphasising the success of the surgery. The sutures were removed, and the patient left the clinic satisfied with his progress.

Following the lymphocele's appearance, the patient could not drive his car. However, 1 month following surgery, during a telephone consultation, the patient joyfully reported that he had undertaken his first drive the previous day, which went exceptionally well and surpassed all expectations. He also noted improved control and functionality of his leg and expressed great optimism for the future.

DISCUSSION

This case report presents the first case of a lymphocele at the groin treated with excision and robot-assisted microsurgical lymphovenous anastomosis using the Symani Surgical System, highlighting a significant advancement in the management of

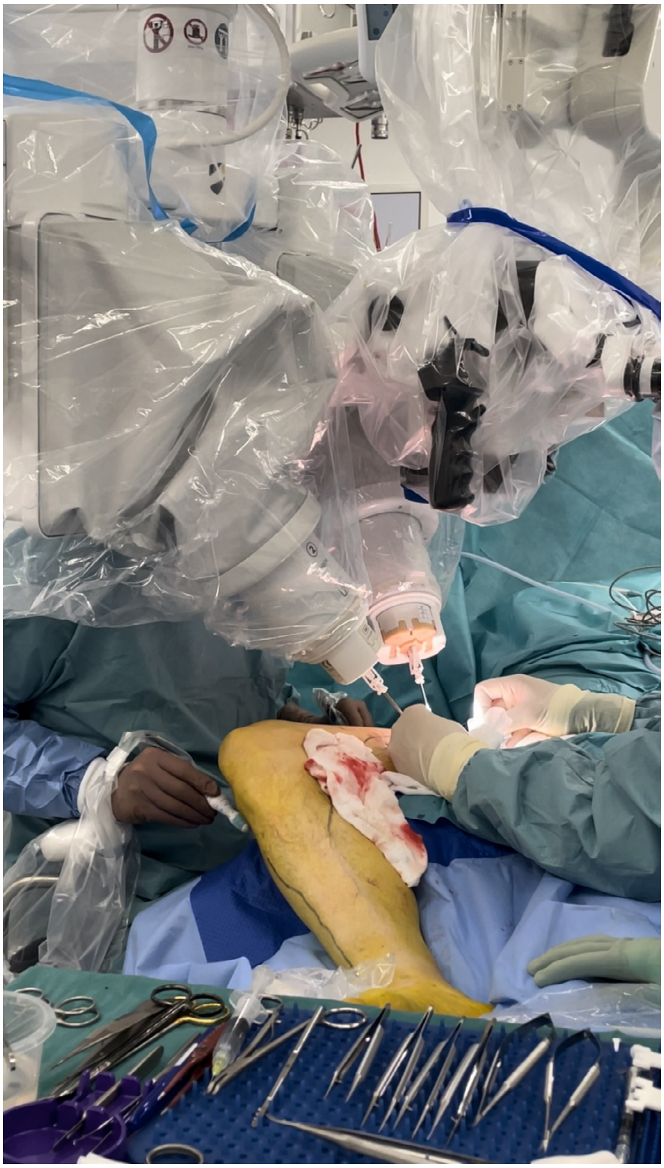
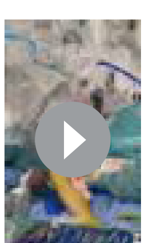


Figure 2 The set-up of the two surgeons using the Symani Surgical System (Medical Microinstruments, Calci, Italy) to perform lymphovenous anastomosis on the patient.

lymphatic disorders. Investigating lymphovenous anastomosis as an alternative approach to ligation in the management of lymphoceles reflects a shift towards innovative approaches aiming to create new, effective lymphatic pathways. When combined with robotic assistance, this method offers a refined precision that surpasses conventional surgical techniques.



Video 2 The surgeons performing robot-assisted lymphovenous anastomosis on the patient.

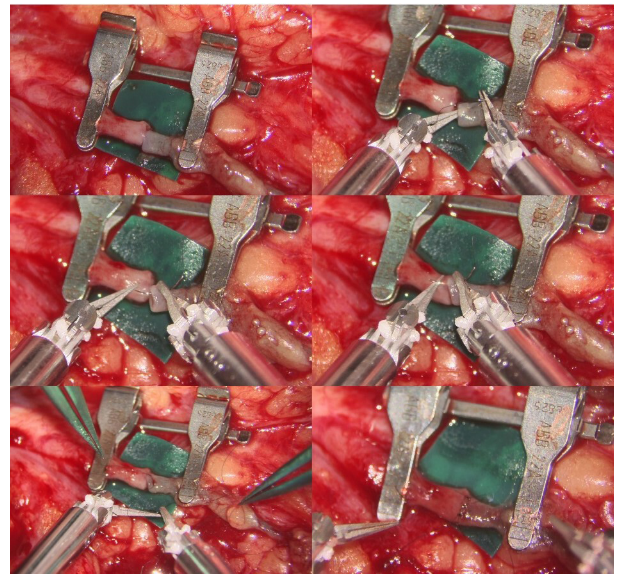


Figure 3 Pictures showing the step-by-step process of the anastomosis using the Symani Surgical System (Medical Microinstruments, Calci, Italy), from the first suture until the final anastomosis.

Treating lymphoceles poses challenges due to their high recurrence rates and varying responses to treatment. These are often situated near crucial structures like blood vessels, nerves and organs, necessitating meticulous surgical planning to minimise risks. While lymphovenous anastomosis is mainly used for secondary lymphoedema, it has also been adapted for lymphocele treatment.[3 7–11] Yet, literature on lymphocele reconstruction, particularly using robotic systems, remains sparse.[12] Conventional lymphovenous anastomosis has been a mainstay in the surgical treatment of lymphatic conditions, including lymphoceles, due to its direct approach and the surgeon's ability to use tactile feedback during the procedure.[3] A comparison between robot-assisted lymphovenous anastomosis and conventional lymphovenous anastomosis highlights each method's unique benefits and hurdles, significantly shaped by the extent of technological use, cost factors and the impact on surgical outcomes.

The robotic surgical platform has gained widespread clinical use in different specialties, including urology, gynaecology and abdominal surgery. However, the introduction into plastic and reconstructive surgery has been lagging behind. The first robot-assisted surgery was invented in 1997 to perform laparoscopic

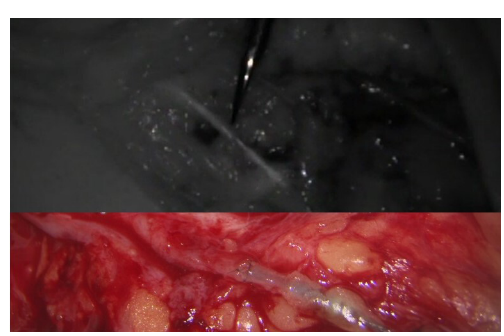


Figure 4 Images from the operation are presented. Above: the lymphovenous anastomosis is illustrated during indocyanine green lymphography. Below: the anastomosis created during the procedure is shown before surgical closure.

Figure 5 14 days postoperatively. The patient presents a full recovery, with no swelling at the groin.

surgery using the da Vinci surgical system (Intuitive Surgical, Sunnyvale, California, USA) approved by the Food and Drug Administration in 2000.[13] It was not until 2007 that the first microsurgical anastomosis was performed by the da Vinci robot for an autologous breast reconstruction using a transverse rectus abdominis muscle flap.[14] This is considered the beginning of robot-assisted microsurgery; however, da Vinci systems are large and powerful, posing challenges when performing microsurgery.[15]

The introduction of the MUSA robot (MicroSure, Eindhoven, The Netherlands) in 2020 represented the first significant step toward robot-assisted microsurgery, equipped with joystick-operated microsurgical instruments. It improves surgeons' performance by providing motion scaling and tremor filtration. However, it requires the surgeon to work in a fixed position.[6 15–17] Two years later, the Symani Surgical System was developed, the only system to date offering wrist-type microinstruments which allow for greater reach. This system supports the surgeon in a comfortable position, translating movements through a co-manipulated robot into precise actions in the operative field, thereby enhancing precision and potentially surgical success.[5 6 17] Given that factors like tremor, precision and accuracy in the human hand can fluctuate and be affected by the surgeon's mental and physical state, employing a robot could improve the surgical results by mitigating these human errors. Additionally, robots offer the benefit of not experiencing physical exhaustion or involuntary movements, unlike their human counterparts.[6]

Lindenblatt *et al* present the first-in-human use of the Symani Surgical System, performing lymphovenous and arterial anastomosis for lymphatic reconstruction.[5] Our experience corroborates with their observations and supports the feasibility of performing robot-assisted microsurgery in humans. The surgical duration of 34 min for performing microsurgical anastomosis in our case also aligns with previous work on the Symani Surgical System, ranging from 16 to 33 min per anastomosis.[15] This time duration will probably decrease as the surgeon becomes more experienced using the surgical system, reaching a learning curve plateau. Compared with traditional lymphovenous anastomosis microsurgery, the duration also aligns with other studies, ranging from 13 to 51 min per anastomosis.[18 19]

However, several challenges could potentially arise with the adoption of robot-assisted systems. First, the adoption of robot-assisted surgery requires acceptance from both clinicians and patients. The integration of new technologies in medical practice necessitates a shift in traditional surgical paradigms, demanding openness from all stakeholders involved.[17] Fortunately, our centre has not encountered any difficulties in this area.

Training surgeons to proficiently use the robotic system poses another significant challenge. Despite the robots' ability to enhance surgical precision, the requisite extensive technical training can be daunting. The development of effective training simulators and programmes to ensure surgeons can harness the full potential of these robotic systems without compromising patient safety is essential for a steep learning curve.[17] Our department has made strides in this area by implementing a simulator that facilitates comprehensive training and certification in robotic surgery.

Moreover, the engineering challenges of developing robot control systems capable of adapting to unexpected events or disturbances during surgery are non-trivial. Such systems are crucial for maintaining the high levels of safety and efficacy expected of robotic surgery. Additionally, the speed and stability of the wireless network are critical to the seamless operation of robotic systems.[17]

Despite these challenges, the benefits of robot-assisted microsurgery are manifold. First, the precision offered by robotic systems is unparalleled, especially in microsurgery, where the margin of error is minimal. By filtering out human tremors, robots enable surgeons to perform delicate procedures with increased accuracy and possibly reduced risks of complications. Another advantage is the potential reduction in surgeon fatigue. Traditional microsurgery often requires lengthy periods of intense concentration and physical steadiness. Robots, unaffected by physical tiredness, can perform consistently over extended periods, potentially leading to better surgical outcomes. However, our experience suggests that robot-assisted surgery can be more exhausting than traditional microsurgery, especially in terms of ergonomics, when an exoscope is not used. Nonetheless, it is imperative to acknowledge that the efficacy of robot-assisted surgery highly depends on the expertise of a proficient surgeon who is not hindered by physical fatigue to execute the procedure with the required precision. Robots cannot supplant the critical role of surgeons; they should instead be viewed upon as an additional instrument to the array of surgical tools, aimed at augmenting the procedure by supporting the surgeon's actions and enhancing the overall execution of the operation. Essentially, the robot acts as a facilitator, amplifying the surgeon's already competent performance.

In summary, this case report supports the application of robot-assisted microsurgery using the Symani Surgical System.

Patient's perspective

I was eagerly anticipating the outcome from this surgery, having undergone treatment four times previously at a different hospital. My confidence in the surgeons was high, and I believe strongly in the success of this procedure. I felt that I received excellent care and enjoyed being a patient at their hospital. Driving my car yesterday for the first time since the lymphocele appeared was a nerve-wracking prospect, given the previous lack of cooperation from my leg. However, the drive went far better than I had imagined, leaving me feeling that I was back on the right path. I am optimistic about what the future holds and thoroughly satisfied with the success of the surgery.

Learning points

- ► We report the first robot-assisted treatment of lymphocele in the groin, with complete recovery.
- ► The employment of the Symani Surgical System demonstrated how robotic assistance can lead to precise surgical outcomes in microsurgical procedures, by enhancing the surgeon's ability to perform intricate manoeuvres.
- ► The successful outcome without postoperative complications and the patient's rapid recovery underscores the efficacy of robot-assisted microsurgery.

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