



Uniportal robotic assisted surgery for anatomical lung resection—First German experience

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Abstract

Background: Uniportal robotic-assisted thoracic surgery (uRATS) has emerged as a promising technique with potential advantages over multiportal approaches. This study aims to evaluate our initial outcomes of uRATS.

Material and Methods: Five patients underwent anatomic lung resections with systematic nodal dissection through a uniportal robotic approach by one surgeon. The results were compared to the results of the first five uniportal video-assisted thoracic surgery (uVATS) anatomical resections performed by the same surgeon.

Results: No adverse events occurred during the uRATS-procedures. Comparable surgical outcomes were observed between uRATS and uVATS, including hospital stays, complication rates, and blood loss. The average procedural time was slightly but non-significantly longer in the uRATS-group. Average pain-scores were lower in the uRATS group. One patient in each group experienced major postoperative complications, with one case of in-hospital mortality in the uRATS-group.

Conclusion: The outcomes of uRATS/uVATS were comparable, highlighting the potential and the feasibility of this technique. Prospective studies comparing the learning curves, complication rate and hospital-stay are required in order to justify the superiority of robotics over uVATS.

KEYWORDS

anatomical lung resections, robotic surgery, uniportal

1 | BACKGROUND

Intuitive Surgical introduced the da Vinci Surgical System, the first commercially available surgical platform, to the market in 2000. As early as 2002, Melfi et al. presented their first experience in thoracic surgery using this system.¹ Since then, robotic-assisted thoracic surgery (RATS) has gained increasing importance in thoracic surgery. RATS has several advantages over thoracoscopy: visualisation of the operating field, accuracy, ergonomics—both for the patient and the

surgeon and suppression of the hand tremor. On the other hand, RATS costs are significantly higher, the surgery lasts longer—at least in the beginning, it is not broadly available and it represents an additional operating technique that a surgeon has to learn. Furthermore, there is conflicting evidence concerning postoperative pain, with some studies suggesting increased pain compared with video-assisted thoracic surgery (VATS), while others dispute this finding. Similarly, the potential reduction in complications associated with RATS is also a topic of debate.^{2–5}

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Besides the absence of high-quality evidence to support the use of the robot in thoracic surgery, more and more surgeons are becoming convinced that the benefits overcome the drawbacks. Consequently, there has been a growing adoption of RATS in Germany.⁶

As far as the robotic surgical approach is concerned, the vast majority of thoracic surgeons use the multiportal approach, which is also recommended by the manufacturer and probably intuitively closer to the multiportal thoracoscopic approach, the approach with which almost every VATS surgeon began his career. However, this approach has several disadvantages including higher risk for post-operative pain, worse cosmetic result as well as longer docking time,⁷ which might be one of its drawbacks in terms of effective utilization of operating rooms, as it will increase their occupancy time.⁸

Uniportal robotic-assisted thoracic surgery (uRATS) was recently introduced,⁹ in order to overcome the aforementioned issues. Despite the fact that this technique has only been performed for a few months now, the procedure has been successfully standardized, allowing even very complex thoracic surgical interventions to be performed worldwide.¹⁰ This approach potentially offers advantages like faster docking time and port placement. It may be cheaper, less painful, and allow easier management in case of emergency.¹¹

Apart from the group, that introduced the uniportal robotic approach, there have been very few publications on uniportal RATS,¹²⁻¹⁴ and it remains uncertain whether this technique and teaching can be replicated and implemented in different settings by different surgeons. The purpose of this paper is to report our first experience with the uniportal robotic approach for anatomic lung resections performed by a single surgeon.

2 | MATERIAL AND METHODS

This study describes a case series consisting of five anatomical lung resections with radical lymphadenectomy using uRATS over a period of 6 weeks in March and April 2023.

All procedures were performed by one surgeon who had previously undergone basic training by Intuitive surgical for console surgeons on the DaVinci platform. Besides basic training, the surgeon participated in a master class on uRATS offered by the only team currently involved in practical and scientific exploration of this technique.¹¹ Beyond this, the robotic experience of the surgeon at the beginning of this study was low, consisting of a total of 15 procedures (10 thymic, 2 diaphragmatic, 2 multiportal lung resections, 1 exploratory).

The results of the initial five uRATS anatomical lung resections were compared to the results of the first five uniportal video-assisted thoracic surgery (uVATS) anatomical resections performed by the same surgeon in the early 2016.

The pain score for each patient was determined by calculating the average of six pain scores evaluated twice a day using the Numerical Analogue Scale during the first three postoperative days. As part of routine clinical practice, patients typically receive two peripheral nonsteroidal analgesics and a paravertebral pain catheter with 0.375% Naropin at a rate of 10 mL/h.

The amount of circulating blood was calculated using Nadler's formula,¹⁵ while the total blood loss was calculated by means of Mercuriali's formula.¹⁶

3 | SURGICAL TECHNIQUE

The patient was placed in a lateral decubitus position. A utility incision measuring approximately 4–5 cm was made in the mid-axillary line on the 6th or 7th intercostal space, depending on the size of the thorax. The Da Vinci robot was introduced from the back of the patient and set to 'thoracic' mode. Three robot arms were docked, with the top trocar (dorsal) housing the camera and the following two accommodating surgical instruments. The remaining undocked arm was closest to the cart (Figure 1).

For the left hand, we utilised the 'bipolar fenestrated forceps' (BFF) as a standard instrument. In right-side procedures, the BFF was positioned in the middle of the incision, whereas in left-side procedures, it was placed at the other end of the incision or most ventrally. The right hand controlled the other docked robot arm, which was positioned most ventrally for right-side procedures and in the middle for left-side procedures. This arm was equipped with the 'Maryland forceps' (MF) and was also used for stapler placement. Since the stapler had a diameter of 12 mm, the 8 mm trocar needed to be exchanged each time. Both the BFF and MF instruments exclusively delivered bipolar energy.

In addition, two other instruments were occasionally used during the procedures. The first instrument was the 'Tip-Up' grasping forceps, which had a suitable length for passing behind specific structures, such as the pulmonary artery, bronchus, and parenchymal bridge. The second instrument was the SynchroSeal, which is a bipolar sealing device.

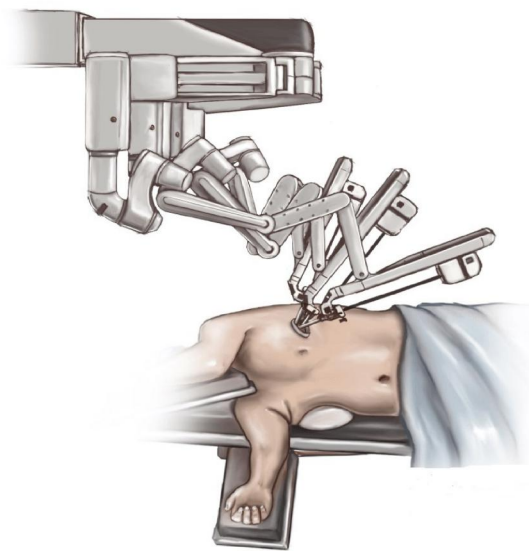


FIGURE 1 Schematic representation of surgical setup (with permission from uniportalrats.com).



Another important instrument used was a longer clamp, which was also employed for VATS subxiphoid access (e.g., D'Amico or Snake, Scanlan), along with an extended suction device (e.g., Denilson, Scanlan).

Furthermore, there were no significant differences in the procedure compared with other methods such as open surgery or VATS (Figure 2, Video 1: <https://youtu.be/KNW6gTZ7haE>). Occasionally, adjustments were required due to variations in the size and width of the trocars used, which differed from those commonly used by the mentioned group (the mentioned group typically utilises transoral robotic surgery (TORS) trocars used in transoral surgery).¹¹ However, these adjustments were effectively managed.

The outcomes of the patients undergoing VATS lobectomy have been published otherwise.¹⁷

The analysis of medical data and publication of results was approved by both the Ethics Board of Heidelberg University (S-430/2017) and the Rheinland-Palatinate Medical Chamber Commission (2021-15979).

4 | RESULTS

No adverse events occurred during the procedures, and there was no need for an additional port. All patients, except one, underwent a fully robotic approach. In one case where the patient had a BMI of 40 kg/m² and underwent right lower lobectomy, the diaphragm was positioned high, resulting in a short chest cavity and limited space. In this situation, we manually placed 2 of our 10 staplers.

The study consisted of four male and one female patient in each group. Table 1 provides the baseline characteristics of the patients in both the uRATS group (uRATS-G) and the uVATS group (uVATS-G).

Table 2 provides a detailed overview of the surgical outcomes and measures between the two groups.

Postoperative complications were observed in one patient from each group. These patients were classified as higher risk due to their

limited preoperative lung function and multiple comorbidities. In the uVATS-G, the complication observed was pneumonia during the postoperative period.

In the uRATS-G, the patient experienced a prolonged air-leak on the basis of severe emphysema followed by respiratory failure and ultimately death on the ninth postoperative day.

5 | DISCUSSION

These findings suggest that both uRATS and uVATS procedures probably yield comparable surgical outcomes, as evidenced by similar hospital stays, complication rates, and blood loss. Notably, no intraoperative adverse events were encountered in either group, highlighting the safety of both techniques.

TABLE 1 Baseline characteristics.

	uRATS-G	uVATS-G	P*
Age (SD), years	67 (12)	64 (10)	0.7
Sex (male)	4	4	1
FEV1 (SD), %	90 (30)	70 (30)	0.45
FEV1/VC (SD), %	67 (14)	74 (9)	0.4
DLCO (SD), %	75 (22)	70 (14)	0.7
BMI (SD), kg/m ²	27.3 (7.4)	26.6 (4)	0.86
ASA (range)	3 (2-4)	3 (3-4)	1
Preoperative CT	3/5	2/5	1

Note: P* should be interpreted with extreme caution and serves here only as a very rough estimation.

Abbreviations: ASA, American Society of Anaesthesiology score; BMI, body mass index; CT, chemotherapy; DLCO, diffusion capacity; FEV1, forced expiratory volume in 1 s; SD, standard deviation; uRATS, uniportal robotic-assisted thoracic surgery; uVATS, uniportal video-assisted thoracic surgery; VC, vital capacity.

TABLE 2 Surgical outcomes.

	uRATS-G	uVATS-G	P*
Surgery duration in min (SD)	216 (42)	196 (29)	0.4
Nr. of staplers (range)	10 (7-13)	7 (4-9)	0.05
TD in days (range)	3 (2-12)	5 (2-5)	0.8
LOS in days (SD)	6.8 (2.4)	7.4 (3)	0.4
Tumor size in cm (SD)	1.2 (0.2)	3.4 (1.6)	0.03
Pain, median at 3POD	0 (0-4)	2 (1-4)	0.39
Blood loss in mL (range)	513 (413-934)	707 (304-1233)	1

Note: P* should be interpreted with extreme caution and serves here only as a very rough estimation.

Abbreviations: LOS, length of hospital stay; Nr., number; POD, postoperative day; SD, standard deviation; TD, thoracic drainage; uRATS, uniportal robotic-assisted thoracic surgery; uVATS, uniportal video-assisted thoracic surgery.

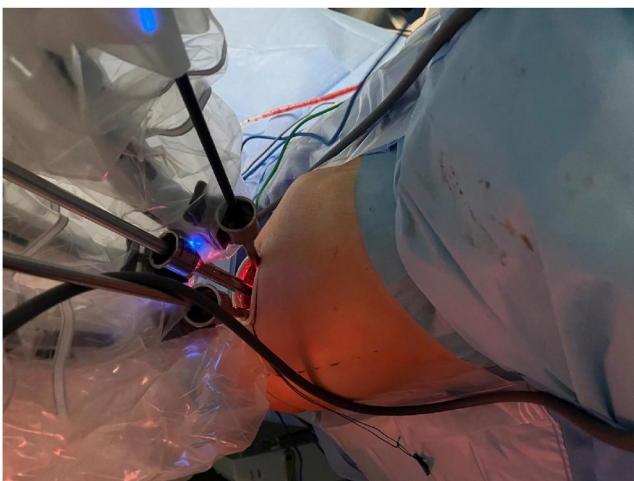


FIGURE 2 Surgical setup.



Although the average surgery time was slightly longer in the uRATS-G, the difference was not statistically significant. The higher utilization of the stapler in the uRATS-G, likely due to the specific technique and instruments used in this approach, may contribute to the potentially increased costs associated with the intervention.

The lower pain score observed in the uRATS-G compared with the uVATS-G should be interpreted with extreme caution as it is likely influenced by different pain management approaches between the two groups. Furthermore, evaluating pain scores in most surgical procedures is inherently challenging, and factors such as individual pain tolerance and subjective reporting can further complicate the interpretation of these scores.

This report is the first mini-report on uRATS conducted by a team outside the working group led by Rivas and Bosinceanu, as well as the group from Shanghai Pulmonary Hospital, which Rivas is officially associated with.

This report provides further insights into the feasibility of uRATS in various environments and settings, even with less experienced surgical teams. It also represents the first experience with uniportal RATS in Germany.

An important difference observed is the need to perform uRATS without the use of specially adapted TORS trocars. These trocars, which are thinner, require further modification to achieve a suitable shape and smoothness. Additionally, they are expensive. This aspect may potentially pose an obstacle to the wider adoption of uRATS, especially until modified trocars specifically designed for uRATS become available in the market.

For experienced thoracic surgeons with prior knowledge of uVATS, uRATS appears to be generally intuitive. However, it does require familiarisation with the technology, equipment, and their limitations. The results suggest that the operating time during the learning curve is slightly longer compared to uniportal video-assisted thoracoscopic surgery (uVATS), and the role of the assistant is significantly different. In uVATS, the assistant is primarily responsible for operating the optics or camera and ensuring optimal visualisation. In uRATS, the assistant is also involved in exposure, instrument handling such as retracting and passing sutures and sponge sticks, and suctioning. Therefore, the learning curve for uRATS is somewhat more complex as it depends not only on the skill of the console surgeon but also on the abilities of the assistant.

The successful completion of five anatomical resections using uRATS, despite encountering two prior unsuccessful attempts including a conversion for a completely stuck lung and a biportal segmentectomy (S3 right), emphasises the critical importance of comprehensive training and educational opportunities in enabling surgeons to adopt and excel in advanced surgical techniques such as uniportal RATS.

However, it is important to acknowledge that these findings are preliminary, and further research and experiences are needed to fully understand the potential advantages and limitations of uRATS. Additionally, the small number of patients in this series limits the ability to draw definitive conclusions.

In conclusion, while this report represents an important initial step in exploring uRATS in different settings, further research and experiences are necessary to fully grasp the potential benefits and limitations of this technique. A phase I randomized controlled trial comparing uniportal and multiportal robotic-assisted thoracic surgery (RATS) should be considered as the subsequent crucial phase in assessing the effects of these surgical approaches on both immediate postoperative and oncologic outcomes.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest related to this research.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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