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Innovations in robotic surgery and recent developments in the SP platform

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In recent years, the field of thoracic surgery has witnessed the emergence of three separate evolutionary branches that have run in parallel at different stages of maturity: single-incision uniportal video-assisted thoracic surgery (uVATS), multiport robotic-assisted surgery (RAS) and the use of alternative access into the thoracic cavity with subxiphoid or subcostal incisions.

The first trend is uniportal or single-incision access for minimally invasive anatomic lung resection, which was first successfully performed and reported by Gonzalez-Rivas over a decade ago (1). Since then, the technique has gained popularity and has benefited from standardized techniques, such that anatomic lung resection as well as thymectomies are routinely performed worldwide. However, the technique is limited by the use of a manual approach with non-articulating instruments, and typically requires an experienced assistant to operate the camera, as well as to retract.

The second trend is multiport RAS. From the time of the first publication of multiport RAS for anatomic lung resection by Melfi *et al.* two decades ago in 2002 (2), RAS has become increasingly popular worldwide for anatomic lung resection and mediastinal mass resection. In the United States, RAS was used in nearly 50% of lobectomies and over 50% of segmentectomies in 2020, with a decline in both open and VATS approaches (3). Compared to VATS, the RAS approach provides 3D vision, wristed instruments, stability and motion scaling to facilitate dissection; however, some surgeons have objected to the use of multiple ports for each of the four robotic arms. Recently, Gonzalez-Rivas reported using the multi-arm da Vinci Xi system

for uniportal thoracic surgery through a single intercostal incision, which combines these first two trends (4).

The third trend is using an alternative access into the chest cavity. The use of a subxiphoid or subcostal incision has attracted interest from both uVATS and RAS surgeons as an alternative access point, either for all the instruments and camera in uVATS or as an alternative port site in multiport RAS. While this incision location is naturally adaptable for anterior mediastinal mass resections, this approach can also provide access into the pleural cavity for lung resections without disrupting the diaphragm. The appeal of this alternative access point is the potential for less pain compared to an intercostal incision, where the intercostal nerve can be traumatized. Interestingly, the theory that fewer incisions in the intercostal space results in less pain has not been borne out convincingly in the VATS literature, and in a recent consensus statement, only half of high-volume uVATS surgeons believed that pain was significantly improved with one incision compared to multiple incisions in the intercostal space (5). In contrast, pain studies comparing intercostal *vs.* subxiphoid/subcostal approaches appear to validate the hypothesis of less pain towards the midline where the intercostal nerves are less vulnerable (6).

Due to recent technological advances, there is interest in coalescing these three trends into one approach: a single port robotic-assisted approach through a subxiphoid or subcostal incision to perform anatomic lung resection or mediastinal mass resection. This may be accomplished with the use of the da Vinci SP (Single Port) system, a four-arm

robotic surgical platform consisting of a 3D articulating camera and three 6 mm instruments entering through one port. The system can be docked to a 2.5 cm trocar or using an integrated access port with a wound protector. Experimental research in cadavers initially demonstrated that this approach is feasible with suitable reach and access (7,8). At the time of this publication, the SP system is not approved for thoracic surgery in the United States or Europe, but it is approved in South Korea where clinical experience is accumulating. In the past year, published data from the Korean surgeons on subxiphoid/subcostal thymectomy have shown excellent results, and their early experience in anatomic lung resection is reported to be safe and effective (9,10).

Based on the published clinical experience from Korea, potential advantages of using the da Vinci SP system include alternative access at the subxiphoid/subcostal location, double articulation of the instruments (wrist as well as joggle or “elbow” joints) to generate better triangulation of instruments at the target anatomy, improved perspective with an articulating 3D camera for a versatile view and the ability to use a 4th arm for retraction. The current difference with SP compared to multiport Xi is that there is no robotic stapler and the bedside assistant must use a laparoscopic stapler side-by-side with the SP system through a single access port. Further technological development of an SP stapler will likely facilitate use and procedure efficiency. Another distinction compared to Xi is that the SP system cannot be used through the intercostal space due to the size. In the meantime, ongoing clinical studies in the United States and Asia will be helpful to further elucidate the feasibility, safety and efficacy of this approach.

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Footnote

Conflicts of Interest: DSO is part-time employed by Intuitive Surgical as a medical advisor

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