Editorial Commentary



# Hybrid operating room: the leading edge of thoracic surgery

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Chen *et al.* report a retrospective comparison of preoperative localization outcomes in the hybrid OR *vs.* CT room for video-assisted thoracoscopic surgery (VATS) surgery (1). The authors employed a CT-guided patent blue vital (PBV) dye localization strategy in this study, supported by previous work demonstrating safety and high efficacy (2,3). However, this previous work employed a 'traditional' approach of using an interventional CT room. Preoperative localization of lung nodules in a hybrid OR equipped with a robotic cone-beam CT (CBCT) was first reported in 2013 (4). Thereafter, several studies reported early experiences with hybrid OR CBCT localization at individual institutions (4-12). The ability to employ CBCT following anesthetic induction offers several potential advantages, including reduced respiratory motion artifact, more stable patient positioning, and decreased patient discomfort. These capabilities may have implications in terms of time, cost savings, and reduction in the rate of localization failure (11). As the authors noted, their study is the first to compare traditional (i.e., CT room) localization with a hybrid OR CBCT approach.

This study retrospectively evaluated 25 consecutive patients undergoing preoperative CT-guided dye localization in the hybrid OR with 50 propensity-matched controls undergoing localization in the CT room (drawn from a total pool of 283 patients). Matching was performed based on operative method, lesion number, depth, and size, among others. Review of Table 1 suggests matching was successful. However, the control cohort was drawn from earlier years than the hybrid OR cohort; this may explain some differences in post-operative outcomes described later. Relatively clear inclusion and exclusion criteria for hybrid OR localization were described—small indeterminate lung nodules 0.5–2 cm in size difficult to localize thoracoscopically, no plan for lobectomy, and <3 cm from the pleura. Conversely, no clear criteria were described for the control cohort other than there being a peripheral small indeterminate lung nodule. This highlights the risks for selection bias in retrospective studies. The higher rate of malignancy in the control group (77% *vs.* 98%) suggests the cohorts may have differed by factors not included in the propensity matching. Localization in the hybrid OR was performed after anesthetic induction and endotracheal intubation, following which the patient was positioned for localization and then repositioned post-localization for VATS on the same table. By comparison, control patients underwent preoperative CT-guided dye localization in the CT room, after which they were transferred to the general ward to await their subsequent surgery.

As procedural times are a key outcome for this study, it is worthwhile to reiterate their definitions. For both groups, localization time was defined as the start of the pre-localization CT scan to the end of the post-localization scan. Likewise, for both groups, surgery time was defined as the first skin incision until completion of wound closure. The global time definition differed between the hybrid OR and control group. For the hybrid OR group, global time was defined as the time of anesthetic induction until extubation. For the control (CT room) group, global time was defined as the start of the pre-localization CT scan until extubation.

The authors concluded that the hybrid OR group had significantly shorter global time (192.6±44.2 *vs.* 244.1±101.8 minutes, P=0.003). This was despite,

surprisingly, a longer localization time (33.1±8.0 *vs.* 22.3±10.7 minutes, P<0.001) and a 'similar' surgical time (107.2±42.5 *vs.* 89±27.1, P=0.060). It is reasonable to wonder if a larger cohort may have been better powered to show a significant difference in operative time. In our own experience, limitations with performing thoracic procedures on an angiography table, including the inability to flex the bed, could reasonably contribute to lengthier operative time in challenging cases.

There are several points to parse from these outcomes. The longer localization time in the hybrid OR certainly surprised us. Although the learning curve of working within the hybrid OR may be a possible explanation, the authors used the same radiologists for all cases and there was no reduction in localization time with later cases (Pearson's R =–0.2315, P=0.375; paper Figure 3), suggesting against this explanation. Instead, we agree with the author's suggestions that differences in sedation, patient position, and CT platforms are likely the main factors at play. That patients in the CT group could easily reposition themselves based on radiologist instruction may be an advantage compared to anesthetized hybrid OR patients. The lack of learning curve also highlights the importance of close cooperation with colleagues in interventional radiology during the initial design and conduct of hybrid OR procedures to ensure effective development of new workflows. The skills developed performing hundreds of lung procedures in the interventional CT room are clearly transferable.

Localization issues aside, another key question is how to explain the large gap in global time, which was around a 50-min reduction with the hybrid OR. The intuitive answer is the clear logistical advantages of having the patient in a single location, avoiding the need for transportation between departments that often involves waiting for porters and completion of handover between nursing staff. These advantages should not be discounted. However, the limitations in the authors' definitions of global time should also be noted. In the control group, time required for placement of a thoracic epidural catheter (seen in paper Figure 1B) may be included since it presumably occurs after localization (whether in a block room near the OR or in the OR itself); this time would not be included in the hybrid OR global time as the epidural is placed presumably prior to anesthetic induction. Likewise, all patients at our institution undergo an assessment by nursing staff upon arrival to the pre-operative holding area to ensure necessary documentation is completed (e.g., allergy bands, consent, surgical site marking, etc.). This is true whether the patient is presenting directly from home or after transport from radiology. This time is included in the global time for the control group (since it follows localization in the CT room) but is not included in the hybrid OR group (which begins after anesthetic induction). Although we don't believe that the epidural nor preoperative checklist completely explain the gap seen in global time, the potential benefit of a hybrid OR approach may be less in practice than the raw numbers immediately suggest. The challenge in interpreting these results highlights the difficulty in designing time outcomes for studies like this, where traditional workflows are significantly altered. The limitations in the global time definition likely reflects the retrospective nature of this study; we suspect these granular timepoints were simply not available.

With regards to postoperative outcomes, the authors noted a shorter duration of chest tube drainage (1±0.4 *vs.* 1.5±0.8 days, P<0.001), but this did not result in a significant difference in postoperative hospital stay (P=0.161). As noted by the authors, the control cohort drew from less recent cases (2013 to 2015) than the hybrid OR cohort (2015 to 2016); implementation of a new chest tube protocol and tubeless uniportal VATS likely had an effect.

All lung nodules were successfully resected in both groups, though two patients in the hybrid OR group did not complete localization due to complications. The first, diaphragm injury into the liver, is not intuitively related to the use of the CBCT and may in theory have also occurred in the CT room had the patient been part of the control cohort. The reduced soft tissue imaging quality of CBCT may have been a contributing factor. The second complication, a large pneumothorax, demonstrates the physiologic consequence of positive pressure ventilation during localization. Positive pressure ventilation during localization may also carry the risk of air embolism, as seen with percutaneous biopsy (13). Pausing ventilation, or short-duration neuromuscular blockade (as suggested by the authors), may be critical preventative measures. Nonetheless, with both complications the advantage of the hybrid OR was demonstrated—the complications were immediately recognized and direct assessment via thoracoscopy could be performed promptly.

Conversely, CT room localization was associated with high rates of small pneumothorax and intrapulmonary focal hemorrhage. This may be related to the improved image quality with modern multislice CT scanners which allowed these minor complications to be readily detected. That there was no large pneumothorax despite 38% of patients

 

having a small pneumothorax corroborates the significant consequence of applying positive pressure ventilation during interventional lung procedures.

The authors also found total radiation exposure was higher in the hybrid room group (953.5±725.4 *vs.* 317.2±183.7 mGy*cm). This likely reflects key differences in the technology of CBCT *vs.* multislice CT scanners (which employed a low-dose, thin-slice protocol). As Chen *et al.* explained, a higher CBCT radiation dose is needed to achieve equivalent soft tissue image quality to conventional CT. However, it is important to recognize that 'excellent' image quality is not necessary for nodule localization. We agree that new protocols are needed for CBCT image quality that better balance the tradeoff between radiation exposure and image quality. Although localization time did not significantly change with case number (paper Figure 3), we do wonder whether radiation dose per case decreased as the radiologists became more comfortable with CBCT image quality.

We would suggest caution in evaluating the cost analysis included in the supplementary material, given some of the caveats the authors themselves noted. Although the procedural costs themselves are similar, the authors did not account for the significant upfront costs associated with constructing a hybrid OR, which is undoubtedly a major consideration for the many institutions without such a facility. Conversely, the interventional CT room used for localization is the same used for CT-guided lung biopsy; such capabilities already exist for many centers managing lung cancers. The opportunity cost associated with using the CT room for localization rather than other procedures is also not explored.

In conclusion, preoperative CT-guided dye localization in the hybrid room was an effective technique for small nodule localization and was associated with reduced total procedure time as well as similar perioperative outcomes compared to localization using a dedicated CT room. This was despite evidence of slightly longer localization time, suggesting the benefits of the hybrid OR are derived from broader logistical efficiencies. Use of the hybrid OR strategy should include consideration for management of positive pressure ventilation physiology and the unique risks that it presents for interventional lung procedures. Overall, the limitations discussed earlier are, in many circumstances, limitations inherent in all retrospective studies; the authors should be commended for their work in this difficult area of research. Prospective studies, particularly ones that are randomized, can better address issues with selection bias and allow more granular data collection as it relates to patient flow.

The hybrid OR in thoracic surgery has many potential benefits. It will allow more rapid advancements in interventional therapeutics, including minimally invasive surgery and robotic surgery. Furthermore, developing a hybrid OR allows early evaluation of workflow considerations related to the deployment of new technologies and procedures. Continued evaluation of these facilities' capabilities and limitations is critical to allow for more effective use of these limited resources.

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## References

1. Chen PH, Hsu HH, Yang SM, et al. Preoperative Dye Localization for Thoracoscopic Lung Surgery: Hybrid Versus Computed Tomography Room. Ann Thorac Surg 2018;106:1661-7.
2. Tseng YH, Lee YF, Hsieh MS, et al. Preoperative

computed tomography-guided dye injection to localize multiple lung nodules for video-assisted thoracoscopic surgery. J Thorac Dis 2016;8:S666-71.
3. Lin MW, Tseng YH, Lee YF, et al. Computed tomography-guided patent blue vital dye localization of pulmonary nodules in uniportal thoracoscopy. J Thorac Cardiovasc Surg 2016;152:535-44.e2.
4. Narayanam S, Gerstle T, Amaral J, et al. Lung tattooing combined with immediate video-assisted thoracoscopic resection (IVATR) as a single procedure in a hybrid room: our institutional experience in a pediatric population. Pediatr Radiol 2013;43:1144-51.
5. Ohtaka K, Takahashi Y, Kaga K, et al. Video-assisted thoracoscopic surgery using mobile computed tomography: New method for locating of small lung nodules. J Cardiothorac Surg 2014;9:110.
6. Gill RR, Zheng Y, Barlow JS, et al. Image-guided video assisted thoracoscopic surgery (iVATS) - phase I-II clinical trial. J Surg Oncol 2015;112:18-25.
7. Zhao ZR, Lau RW, Ng CS. Hybrid theatre and alternative localization techniques in conventional and single-port video-assisted thoracoscopic surgery. J Thorac Dis 2016;8:S319-27.
8. Yang SM, Ko WC, Lin MW, et al. Image-guided thoracoscopic surgery with dye localization in a hybrid operating room. J Thorac Dis 2016;8:S681-S689.
9. Ujiie H, Kato T, Hu HP, et al. A novel minimally invasive near-infrared thoracoscopic localization technique of small pulmonary nodules: A phase I feasibility trial. J Thorac Cardiovasc Surg 2017;154:702-11.
10. Hsieh MJ, Wen CT, Fang HY, et al. Learning curve of image-guided video-assisted thoracoscopic surgery for small pulmonary nodules: A prospective analysis of 30 initial patients. J Thorac Cardiovasc Surg 2018;155:1825-32.e1.
11. Ujiie H, Effat A, Yasufuku K. Image-guided thoracic surgery in the hybrid operation room. J Vis Surg 2017;3:148.
12. Ujiie H, Gregor A, Kinoshita T, et al. MA23.10 Cone-Beam Computed Tomography-Guided Microcoil Localization of Pulmonary Nodules During Video-Assisted Thoracic Surgery. J Thorac Oncol 2018;13:S441.
13. Kazimirko DN, Beam WB, Saleh K, et al. Beware of positive pressure: coronary artery air embolism following percutaneous lung biopsy. Radiol Case Rep 2016;11:344-7.

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