Open Journal of Surgery

Brief Report

Cost Analysis of Hybrid Operation Room *versus* Non-Hybrid use in General Thoracic Surgery -

Melissa Shafer[1], Yorick Schut[2], Alessandro Radaelli[2] and Carsten Schroeder[1,3]*

[1]Department of Surgery, Augusta University Medical Center, 1120 15th Street, Augusta, GA 30912, USA

[2]Philips, Image Guided Therapy, Veenpluis 6, 5684 PC, Best, The Netherlands

[3]Department of Surgery, Charles George VA Medical Center, 1100 Tunnel Rd, Asheville, NC, 28805, USA

***Address for Correspondence:** Carsten Schroeder, Department of Surgery, Charles George VA Medical Center, 1100 Tunnel Rd, Asheville, NC, 28805, USA, Tel: +1-828-298-7911/ +1-706-721-4726; Fax: +1-828-299-2567; ORCID ID: 0000-0001-5076-1375;
E-mail: carsten.schroeder@va.gov/ cschroeder@augusta.edu

Submitted: 30 March 2020; **Approved:** 06 April 2020; **Published:** 08 April 2020

Cite this article: Shafer M, Schut Y, Radaelli A, Schroeder C. Cost Analysis of Hybrid Operation Room *versus* Non-Hybrid use in General Thoracic Surgery. Open J Surg. 2020;4(2): 025-028.

ISSN: 2689-0593

ISSN: 2689-0593

CENTRAL MESSAGE

Cost analysis of "one-stop-shop" Hybrid Operation Room use in General Thoracic Surgery reveals a cost savings of over $ 5000 per case, when compared to multiple appointment non-Hybrid use.

OBJECTIVE

The use of the Hybrid OR was first reported in 2013 for intraoperative localization of lung lesions [1]. In the past decade, Electromagnetic Navigation Bronchoscopy (ENB) emerged as a useful technology for lung localization for biopsies and marking of lung lesions, or deployment of fiducials markers [2].

These days, the combination of Hybrid OR and ENB for lung lesion localization has shown a significant increase in the accuracy of diagnosis and treatment, which become viable and suitable in selected patients [3].

The advent of the Hybrid OR on-table CT-scan created the opportunity for innovative, stream-lined approaches to diagnosis, staging, and ultimately, treatment for the thoracic surgical oncologist [4,5].

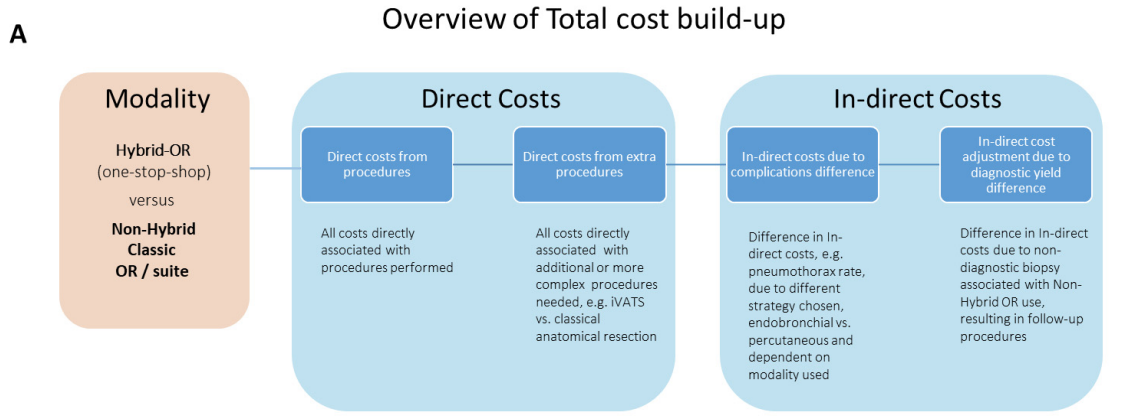
The financial impact for the institution however, and whether there is a substantial return on investment is currently unknown. We therefore analyzed the cost of 35 consecutive hybrid OR cases compared to historical data on non-Hybrid OR cases.

METHODS

An IRB approved (AU1128265-7) prospective database review of 35 consecutive patients was performed. Patients underwent different combinations of navigation bronchoscopy, endobronchial ultrasound (EBUS), CT-guided biopsy, and image-guided thoracoscopic surgical resection (iVATS), as indicated, in the Hybrid OR. The costs of the procedures were available *via* the department financial reporting. Costs of a comparative non-Hybrid OR setting were modeled (Figure 1) by using an aggregated formula, using departmental cross charges and assuming patient pathway would be the same. The formula was determined as followed:

$$Procedural\ Non-Hybrid\ costs = \left(Cost_{Broncoscopy} + Dummy_{Yielddifference} * Cost_{Yielddifference} + Dummy_{Navigationonly} * GA_{Occurence} * Costs_{GA}\right) + \left(Cost_{Percutaneous} + Dummy_{pneumotorax} * Cost_{pneumotorax}\right) + \left(Cost_{Surgical} + Dummy_{Lobedifference} * Cost_{Lobedifference}\right)$$

where $Cost_{Broncoscopy}$ is described as the direct bronchoscopy cross-charge costs from department. Where $Dummy_{Yielddifference}$ is a dummy variable used to describe the occurrence of a non-surgical procedure with only bronchoscopy and/or CT Guided percutaneous biopsy to address the exclusion of advanced guidance within the Hybrid OR with Cone beam CT technology. Where $Cost_{Yielddifference}$ is stated as the implied costs of re-biopsy, taken the yield difference between non-Hybrid and Hybrid OR of 20%, given the difference in diagnostic yield defined and described in the NAVIGATE trial for ENB [6,7] in (non-Hybrid) compared to diagnostic yield in a Hybrid setting [3] given the lack of navigational technology. Where $Dummy_{Navigationonly}$ describes the occurrence of a navigational bronchoscopy procedure only where no follow-up procedures occurred to address the need



B

Types of procedures	Yield	Pneumothorax rate	Need for Chest tube when Pneumothorax	Costs Chest tube	Costs Overnight stay***
Navigational Bronchoscopy Biopsy	70-85%	1.5%-5%*	50%	$1,473.50	$1,789.00
CT Guided Biopsy	95%	15%-40%**	50%	$1,473.50	$1,789.00

*Joseph E. Cox et al., Transthoracic Needle Aspiration Biopsy: Variables That Affect Risk of Pneumothorax. Radiology, 1999
**Wang Memoli JS, Nietert PJ, Silvestri GA. Meta-analysis of guided bronchoscopy for the evaluation of the pulmonary nodule. Chest 2012; 142:385–393.
****One overnight stay mandatory when Pneumothorax occurs*

Figure 1: A: Overview of total cost using direct and indirect cost measures for the different modalities of Hybrid and non-Hybrid operation room (OR) use. B: Example of assessment of yield, complication rate, and associated cost for bronchoscopy and CT-guided biopsy.

ISSN: 2689-0593

for general anesthesia in a non-Hybrid setting for navigational bronchoscopes. Where $GA_{Occurence}$ describes the chance of using general anesthesia, estimated to be 81.4% following literate [7] and where $Costs_{GA}$ describes the direct costs for general anesthesia. Where $Cost_{Percutaneous}$ describes the direct cross-charge for non-hybrid CT Guided costs. Where $Dummy_{pneumotorax}$ is a dummy variable used to describe the occurrence of an unsuccessful CT guided biopsy followed by a surgical biopsy to address the elevated chance of pneumothorax. Where $Cost_{pneumotorax}$ describes the direct costs of pneumothorax with chest tube given the chance of occurrence. Where $Cost_{Surgical}$ describes the direct cross-charged costs for the individual surgical procedure and where $Dummy_{Lobedifference}$ is a dummy variable to describe the occurrence of multiple to address that these procedures would have required an more advanced procedures eg., lobectomies due to no availability of iVATS in the non-Hybrid setting. At last, $Cost_{Lobedifference}$ describes the direct costs difference between a surgical wedge and lobectomy for non-palpablelesions instead of limited resection *via* iVATS.

The "one-stop-shop" solution of the hybrid OR eliminated the usual involvement of different locations and multiple appointments, each associated with their own diagnostic yield, morbidity and cost.

RESULTS

34/35 (97%) patients had a successful same day diagnosis using a combination of techniques in the Hybrid OR. The overall cost in the Hybrid OR was lower ($ 194,487) compared to the non-Hybrid environment ($ 250,124). This was mainly driven by the clear cost advantage of the 11 surgical cases. The cost of these surgical cases in the Hybrid OR amounted to $ 80,823, compared to $ 134,834 if the procedures would have been performed without the benefit of the Hybrid OR (Figure 2).

The cost for 24 non-surgical (bronchoscopy and percutaneous) procedures was higher in the Hybrid OR setting ($ 113,664) compared to the costs calculated from a non-OR setting ($ 111,857), although this difference is less than2%.

Our modeling revealed that the need for additional diagnostic procedures, if performed in a non-Hybrid OR setting, would result in additional costs of $ 5,043 per case. This was due to lower yield, higher complication rate and additional direct/ in-direct costs when performed in a non-Hybrid OR setting.

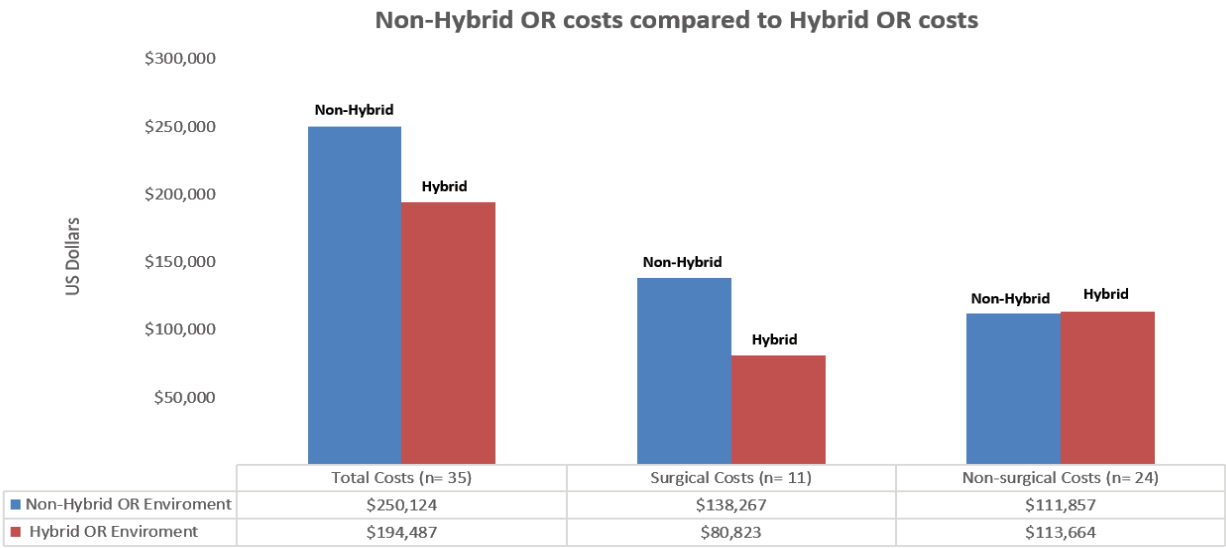
CONCLUSION

The Hybrid-OR is an established concept in cardiac and vascular surgery that is receiving increased attention in general thoracic surgery due to its value in streamlining diagnosis and treatment for lung cancer patients [4,5].

As the return of investment and financial impact of new technology is key to its broader adoption, in this report we focused on the financial impact of the Hybrid OR in general thoracic surgery.

An important element in our cost analysis is the availability of granular data on departmental costs associated with the Hybrid OR and the procedures in the control arm, thus avoiding the need for estimation or extrapolation through charges and billing algorithms and providing a real-life example of incurred costs. However, the total costs associated with the procedures in the non-Hybrid OR arm required a model for occurrence of additional procedures subsequent to lower diagnostic yield or higher complications [3,6]. On the other hand, cost data for each procedure was obtained from the departmental cost database within the same institution, eliminating hospital and regional differences in the cost assessment.

Our key finding is that the "same-day-diagnosis to treatment" paradigm is more cost effective than multiple procedures performed by multiple providers and multiple appointments. Furthermore, the Hybrid OR one-day approach leads to over $ 5000 savings per case compared to multiple procedures and multiple appointments. The



	Total Costs (n= 35)	Surgical Costs (n= 11)	Non-surgical Costs (n= 24)
Non-Hybrid OR Enviroment	$250,124	$138,267	$111,857
Hybrid OR Enviroment	$194,487	$80,823	$113,664

Figure 2: Non-Hybrid Operation Room cost compared to Hybrid Operation Room. Costs were taken from actual hospital data and modeled with the cost for repeat procedures due to yield and added cost for complication and additional hospital admission.

main source of saving was the lower occurrence of complications and higher diagnostic accuracy, avoiding subsequent procedures. We see that for non-surgical cases the costs tend to be similar, driven by the increased diagnostic capabilities in the Hybrid OR setting.

In conclusion, the Hybrid OR offers an economical and streamlined approach to the treatment of lung cancer, the significance of which lies in the improved survival seen in earlier treatment of early-stage lung cancers.

REFERENCES

1. Ng CS, Lau KK, Gonzalez Rivas D, Rocco G. Evolution in surgical approach and techniques for lung cancer. Thorax 2013. 68: 681. https://bit.ly/2UQb3Qd
2. Zhao ZR, Lau RW, Ng CS. Hybrid theater alternative localization technique in conventional and single port video-assisted thoracoscopic surgery. J Thorac Dis. 2016; 8: 319-327. **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed/27014480
3. Pritchett M, Schampaert S, de Groot JAH, Schirmer CC, van der Bom I. Cone-beam ct with augmented fluoroscopy combined with electromagnetic navigation bronchoscopy for biopsy of pulmonary nodules. J Bronchology Interv Pulmonol. 2018; 25: 274-282. **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed/30179922
4. Schroeder C, Chung JM, Mitchell A, Dillard TA, Radaelli A, Schampaert S. Using the hybrid operating room in thoracic surgery: A paradigm shift. Innovations. 2018; 13: 372-377. **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed/30119053
5. Drevets P, Chung JM, Schampaert S, Schroeder C. Hybrid operating room: One-stop-shop for diagnosis, staging, and treatment. Innovations. 2019; 14: 463-467. **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed/31343900
6. Huo J, Xu Y, Sheu T, Volk RJ, Shih YT. Complication Rates and Downstream Medical Costs Associated With Invasive Diagnostic Procedures for Lung Abnormalities in the Community Setting. JAMA Intern Med. 2019; 179: 324-332. **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed/30640382
7. Khandhar SJ, Bowling MR, Flandes J, Gildea TR, Hood KL, Krimsky WS, et al. Electromagnetic navigation bronchoscopy to access lung lesions in 1,000 subjects: First results of the prospective, multicenter NAVIGATE study. BMC Pulm Med. 2017; 17: 59. **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed/28399830