CADTH Reference List

Thoracic Surgery and Neurosurgery in the Hybrid Operating Room

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Summary of Abstracts

Authors: Camille Santos, Monika Mierzwinski-Urban

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Key Messages

- We found 6 nonrandomized studies about the clinical effectiveness of thoracic surgery conducted in a hybrid operating room.
- We found 3 nonrandomized studies about the clinical effectiveness of neurosurgery conducted in a hybrid operating room.

Research Questions

1. What is the clinical effectiveness of thoracic surgery conducted in a hybrid operating room?
2. What is the clinical effectiveness of neurosurgery conducted in a hybrid operating room?

Methods

Literature Search Methods

An information specialist conducted a literature search on key resources including MEDLINE, the Cochrane Database of Systematic Reviews, the International HTA Database, the websites of Canadian and major international health technology agencies, as well as a focused internet search. The search approach was customized to retrieve a limited set of results, balancing comprehensiveness with relevancy. The search strategy comprised both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. Search concepts were developed based on the elements of the research questions and selection criteria. The main search concepts were thoracic surgery, neurosurgery, hybrid operating rooms, and hybrid emergency rooms. The search was completed on March 9, 2023, and limited to English-language documents published since January 1, 2018. Internet links were provided, where available.

Selection Criteria and Summary Methods

One reviewer screened literature search results (titles and abstracts) and selected publications according to the inclusion criteria presented in Table 1. Full texts of study publications were not reviewed. The Overall Summary of Findings was based on information available in the abstracts of selected publications.

Table 1: Selection Criteria

Criteria	Description
Population	Q1: Patients undergoing thoracic surgery Q2: Patients undergoing neurosurgery
Intervention	Surgery performed in a hybrid operating room
Comparator	Surgery performed in a standard operating room

Criteria	Description
Outcomes	Clinical benefits (e.g., postoperative functional status, length of hospital stay, health-related quality of life, patient satisfaction, operative time) and harms (e.g., rates of adverse events, hospital readmission, surgical revisions, complications [e.g., infections])
Study designs	Health technology assessments, systematic reviews, randomized controlled trials, nonrandomized studies

Results

Nine relevant nonrandomized studies were identified for this report.[1-9] Six nonrandomized studies were identified regarding the clinical effectiveness of thoracic surgery conducted in a hybrid operating room (HOR).[1-6] Three nonrandomized studies were identified regarding the clinical effectiveness of neurosurgery conducted in a HOR.[7-9] No relevant health technology assessments, systematic reviews, or randomized controlled trials were identified.

Additional references of potential interest that did not meet the inclusion criteria are provided in Appendix 1.

Overall Summary of Findings

Six nonrandomized studies were identified regarding the clinical effectiveness of conducting thoracic surgery in a HOR, specifically in patients with pulmonary nodules.[1-6] The majority of the studies on patients that underwent pulmonary surgery compared intraoperative CT-guided localization in a HOR to preoperative CT localization in a traditional CT room.[1-5] Chao et al.[2] observed that intraoperative CT resulted in similar success and complication rates as preoperative CT localization with shorter procedural time and lower radiation exposure. Chen et al.[5] also found that CT-guided localization in a HOR led to similar perioperative and postoperative outcomes with shorter global time when compared to traditional localization in a CT room. Another study concluded that intraoperative CT in a HOR provided shorter time from localization to incision and fewer complications than traditional CT.[3] The same study found similar operation time, blood loss, and length of hospital stay between the 2 groups.[3] Two studies found significantly longer time under anesthesia with intraoperative CT than preoperative CT.[2,4] Authors of 1 study found cone beam CT-guided localization in a HOR resulted in similar marking accuracy as X-ray guided marking and CT-guided percutaneous injection without causing secondary pneumothorax.[1] One nonrandomized study on thoracic surgery did not specify imaging modality used for localization in HOR, but authors concluded that image-guided lung resection led to decreased time at risk for pneumothorax and risk of hookwire dislodgement compared to standard hookwire localization.[6]

Three nonrandomized studies were identified regarding the clinical effectiveness of conducting neurosurgery in a HOR.[7-9] Of these, 2 studies were on patients with brain arteriovenous malformations (BAVM),[7,8] whereas 1 study focused on patients with severe traumatic brain injuries.[9] One of the nonrandomized studies on BAVM found that neurosurgery in the HOR was effective for the removal high-grade BAVM.[7] The other study on patients with BAVM observed that neurosurgery in a HOR resulted in a lower mortality rate, higher

radiological cure rate, and a higher rate of good outcomes compared to traditional surgery.[8] For the treatment of severe traumatic brain injuries, the hybrid emergency room was significantly associated with a reduction in unfavourable outcomes and time to CT exam and operation compared to conventional treatment.[9] Refer to Table 2 for a detailed summary of all nonrandomized studies included in this report.

Table 2: Summary of Included Nonrandomized Studies

Study citation	Study design, population	Intervention and comparator(s)	Relevant outcome(s)	Authors' conclusions
Thoracic surgery				
Anamaya et al. (2021)[1]	**Study design:** Prospective cohort **Population:** Patients with small pulmonary nodules **N** = 61	**Intervention:** Cone-beam CT and augmented fluoroscopy-guided virtual bronchoscope-assisted injection in the HOR **Comparator:** Percutaneous CT guided injection, X-ray fluoroscopy-guided virtual bronchoscopy-assisted injection	Secondary pneumothorax	The cone-beam CT and augmented fluoroscopy-guided virtual bronchoscope-assisted injection in the HOR resulted in similar accuracy as comparators without causing secondary pneumothorax.
Chao et al. (2020)[2]	**Study design**: Retrospective study **Population**: Patients with multiple ipsilateral pulmonary nodules **N** = 54	**Intervention:** Intraoperative CT-guided localization **Comparator:** Preoperative CT-guided localization	Procedural efficacy, patient safety, and radiation exposure	The success and complication rates were similar between the two groups. The intervention shortened procedural time and radiation exposure but general anesthesia time for patients was significantly longer compared to the preoperative CT-guided localization.
Cheng et al. (2020)[3]	**Study design**: Retrospective study **Population**: Patients undergoing thoracoscopic lung resection **N** = 126	**Intervention:** Image guided VATs with cone beam CT **Comparator:** Traditional CT room localization	Time from localization to incision, success rate, complication rate, operation time, blood loss, and length of hospital stay	Image guided VATs provides shorter time from localization to skin incision with fewer complications than the traditional CT localization. No significant differences were observed in operation methods, operation time, blood loss, and length of hospital stay.
Chao et al. (2018)[4]	**Study design**: Prospective study **Population**: Patients with small and deep solitary pulmonary nodules **N** = 64	**Intervention:** Intraoperative CT guided lung tumour localization and resection **Comparator:** Conventional 2-stage preoperative CT	Efficacy, safety, and radiation exposure	No difference in localization procedural time and radiation exposure between groups was observed. However, the use of a HOR reduced patient time at risk, as well as increased time under general anesthesia

Study citation	Study design, population	Intervention and comparator(s)	Relevant outcome(s)	Authors' conclusions
				and total operating room utilization time.
Chen et al (2018)[5]	**Study design**: Retrospective study study **Population**: Patients undergoing thoracoscopic lung tumour surgery **N** = 308	**Intervention:** CT guided dye localization in a HOR **Comparator:** Preoperative CT guided localization in a traditional CT room	Localization time, global time, success, morbidity rate	CT guided dye localization in a HOR resulted in shorter global time and similar perioperative and postoperative outcomes compared with localization in a traditional room.
Yu et al. (2018)[6]	**Study design**: Retrospective cohort **Population**: Patients undergoing thoracoscopic resection **N** = 8	**Intervention:** Image-guided VATS **Comparator:** Standard hookwire localization and VATS	'At-risk' period for pneumothorax, risk of hookwire dislodgement	Image-guided VATS led to decreased 'at-risk' period for pneumothorax progression and hookwire dislodgement. Standard hookwire dislodgement had a higher risk of hookwire dislodgement.
Neurosurgery				
Quan et al. (2022)[7]	**Study design**: Prospective study with historical controls **Population**: Patient with high-grade brain AVMs **N** = 102	**Intervention:** 1-stop hybrid brain AVM treatment in a HOR **Comparator:** High-grade brain AVM patient who underwent surgery	Procedural complications (e.g., hemorrhage, neurological deficit, seizure)	1-stop hybrid brain AVM is safe and effective for removal of high-grade brain AVMs, especially for patients with diffuse or complex angioarchitecture.
Wen et al. (2019)[8]	**Study design**: Retrospective study **Population**: Patient with cerebral AVM **N** = 74	**Intervention:** hybrid operation (i.e., resection, intraoperative angiography or endovascular embolization) **Comparator:** non-hybrid operation. (i.e., microsurgical resection or endovascular embolization, or microsurgery combined with embolization in multiple steps)	Mortality rate, post-operation rehemorrhagia, radiological cure rate, and rate of good outcomes	The hybrid operation resulted in a lower mortality rate, higher radiological cure rate, and a higher rate of good outcomes. Additionally, no patients that underwent a hybrid operation experienced post-operation rehemorrhagia.

Study citation	Study design, population	Intervention and comparator(s)	Relevant outcome(s)	Authors' conclusions
Kinoshita et al. (2018)[9]	**Study design**: Retrospective cohort **Population**: Patient with severe TBI **N** = 158	**Intervention:** Treatment in a hybrid emergency room **Comparator:** Conventional treatment	Unfavourable outcomes at 6 months after injury, time from arrival to the start of CT exam and operation	Treatment of TBIs in hybrid emergency rooms was significantly associated with a reduction in unfavourable outcomes and time to CT exam and operation compared to conventional treatment of severe TBIs

AVM = arteriovenous malformation; HOR = hybrid operating room; TBI = traumatic brain injury; VATS = video-assisted thoracic surgery.

References

Health Technology Assessments

No literature identified.

Systematic Reviews

No literature identified.

Randomized Controlled Trials

No literature identified.

Non-Randomized Studies

Thoracic Surgery

1. Anayama T, Yamamoto M, Hirohashi K, et al. The accuracy of cone-beam computed tomography and augmented fluoroscopy-guided bronchoscopic marking of multiple small-sized pulmonary nodules in a hybrid operating room: a retrospective cohort study. *Quant Imaging Med Surg*. 2021;11(2):725-736. PubMed

2. Chao YK, Fang HY, Pan KT, Wen CT, Hsieh MJ. Preoperative versus intraoperative image-guided localization of multiple ipsilateral lung nodules. *Eur J Cardiothorac Surg*. 2020;57(3):488-495. PubMed

3. Cheng YF, Chen HC, Ke PC, et al. Image-guided video-assisted thoracoscopic surgery with Artis Pheno for pulmonary nodule resection. *J Thorac Dis*. 2020;12(4):1342-1349. PubMed

4. Chao YK, Pan KT, Wen CT, Fang HY, Hsieh MJ. A comparison of efficacy and safety of preoperative versus intraoperative computed tomography-guided thoracoscopic lung resection. *J Thorac Cardiovasc Surg*. 11 2018;156(5):1974-1983.e1. PubMed

5. Chen PH, Hsu HH, Yang SM, et al. Preoperative dye localization for thoracoscopic lung surgery: hybrid versus computed tomography room. *Ann Thorac Surg*. 12 2018;106(6):1661-1667. PubMed

6. Yu PSY, Man Chu C, Lau RWH, et al. Video-assisted thoracic surgery for tiny pulmonary nodules with real-time image guidance in the hybrid theatre: the initial experience. *J Thorac Dis*. May 2018;10(5):2933-2939. PubMed

Neurosurgery

7. Quan K, Liu Y, Wang Y, et al. Treatment of high-grade brain arteriovenous malformations using a hybrid operating room: a prospective single-arm study. *Clin Neurol Neurosurg*. Nov 12 2022;224:107517. PubMed

8. Wen J, Lu J, Wu X, et al. Combined microsurgery and endovascular intervention in one-stop for treatment of cerebral arteriovenous malformation: the efficacy of a hybrid operation. *Cell Transplant*. 08 2019;28(8):1018-1024. PubMed

9. Kinoshita T, Hayashi M, Yamakawa K, et al. Effect of the hybrid emergency room system on functional outcome in patients with severe traumatic brain injury. *World Neurosurg*. Oct 2018;118:e792-e799. PubMed

Appendix 1: References of Potential Interest

Systematic Reviews

Unclear Comparator

Jin H, Liu J. Application of the hybrid operating room in surgery: a systematic review. *J Invest Surg*. Feb 2022;35(2):378-389. PubMed

Jin H, Lu L, Liu J, Cui M. A systematic review on the application of the hybrid operating room in surgery: experiences and challenges. *Updates Surg*. Apr 2022;74(2):403-415. PubMed

Scoping Review

Spenkelink IM, Heidkamp J, Futterer JJ, Rovers MM. Image-guided procedures in the hybrid operating room: a systematic scoping review. *PLoS One*. Apr 1 2022;17(4):e0266341. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8975112/ Accessed 2023 Mar 14. PubMed

Alternative Population – Severe Trauma

Khoo CY, Liew TYS, Mathur S. Systematic review of the efficacy of a hybrid operating theatre in the management of severe trauma. *World J Emerg Surg*. 2021;16(1):43. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8403370/ Accessed 2023 Mar 14. PubMed

Non-Randomized Studies

Single Arm Studies

Gomez-Amador JL, Valencia-Ramos CG, Sangrador-Deitos MV, et al. Roadmapping technique in the hybrid operating room for the microsurgical treatment of complex intracranial aneurysms. *J Cerebrovasc Endovasc Neurosurg*. Jan 05 2023. PubMed

Chang CJ, Lu CH, Gao X, Fang HY, Chao YK. Safety and efficacy of cone-beam computed tomography-guided lung tumor localization with a near-infrared marker: a retrospective study of 175 patients. *Life (Basel)*. Mar 28 2022;12(4):494. PubMed

Gilberto GM, Falsarella PM, Andrade JR, et al. Lung nodule localization in hybrid room before minimally invasive thoracic surgery: series of 20 cases and literature review. *Einstein (Sao Paulo)*. 2022;20:eAO6665. PubMed

Jiang Y, Zeng C, Zhang Y, Xu X, Qiu H, Jiang W. Multimodality treatment of brain arteriovenous malformations with one-staged hybrid operation: clinical characteristics and long-term prognosis. *Dis Markers*. 2022;2022:2559004. PubMed

Yang SM, Chung WY, Ko HJ, et al. Single-stage augmented fluoroscopic bronchoscopy localization and thoracoscopic resection of small pulmonary nodules in a hybrid operating room. *Eur J Cardiothorac Surg*. Dec 02 2022;63(1):02. PubMed

Yue JK, Chang D, Caton MT, Jr., et al. The Hybrid operative suite with intraoperative biplane rotational angiography in pediatric cerebrovascular neurosurgery: utility and lessons learned. *Pediatr Neurosurg*. 2022; 57(4):245-259. PubMed

Zhang Q, Wang Z, Liu Y, et al. Application of simultaneous localization of multiple pulmonary nodules in a hybrid operating room for uniportal video-assisted thoracic surgery. *Int J Gen Med*. 2022;15:1429-1435. PubMed

Kato N, Ishibashi T, Maruyama F, et al. Clinical outcomes of procedures combining endovascular embolization with a direct surgical approach in a hybrid operating room for the treatment of refractory dural arteriovenous fistulas. *Surg Neurol Int*. 2021;12:439. PubMed

Song J, Li P, Tian Y, et al. One-stage treatment in a hybrid operation room to cure brain arteriovenous malformation: a single-center experience. *World Neurosurg*. 03 2021;147():e85-e97. PubMed

Xin C, Luo WT, Zhao WY, et al. Combined endovascular and surgical treatment for brain arteriovenous malformations in biplanar hybrid operating room. *Curr Med Sci*. Aug 2021;41(4):782-787. PubMed

Liang CC, Liao CH, Cheng YF, et al. Bilateral lung nodules resection by image-guided video-assisted thoracoscopic surgery: a case series. *J Cardiothorac Surg*. Jul 29 2020;15(1):203. PubMed

Mazza F, Venturino M, Peano E, et al. Single-stage localization and thoracoscopic removal of nonpalpable pulmonary nodules in a hybrid operating room. *Innovations (Phila)*. Nov/Dec 2020;15(6):555-562. PubMed

Park JH, Lee JY, Jeon HJ, Lim BC, Park SW, Cho BM. Safety and completeness of using indocyanine green videoangiography combined with digital subtraction angiography for aneurysm surgery in a hybrid operating theater. *Neurosurg Rev*. Aug 2020;43(4):1163-1171. PubMed

Shin Y, Sunada H, Shiraishi Y, et al. Navigation-assisted full-endoscopic spine surgery: a technical note. *J Spine Surg*. Jun 2020;6(2):513-520. PubMed

Zhang N, Xin WQ. Application of hybrid operating rooms for clipping large or giant intracranial carotid-ophthalmic aneurysms. *World J Clin Cases*. Nov 06 2020;8(21):5149-5158. PubMed

Zhang N, Xin WQ. Application of hybrid operating rooms for treating spinal dural arteriovenous fistula. *World J Clin Cases*. Mar 26 2020;8(6):1056-1064. PubMed

Bohoun CA, Naito K, Yamagata T, Tamrakar S, Ohata K, Takami T. Safety and accuracy of spinal instrumentation surgery in a hybrid operating room with an intraoperative cone-beam computed tomography. *Neurosurg Rev*. Jun 2019;42(2):417-426. PubMed

Chao YK, Leow OQY, Wen CT, Fang HY. Image-guided thoracoscopic lung resection using a dual-marker localization technique in a hybrid operating room. *Surg Endosc*. 11 2019;33(11):3858-3863. PubMed

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Chao YK, Wen CT, Fang HY, Hsieh MJ. A single-center experience of 100 image-guided video-assisted thoracoscopic surgery procedures. *J Thorac Dis*. Jun 2018;10(Suppl 14):S1624-S1630. PubMed

Fumimoto S, Sato K, Koyama M, et al. Combined lipiodol marking and video-assisted thoracoscopic surgery in a hybrid operating room. *J Thorac Dis*. May 2018;10(5):2940-2947. PubMed

Gruter BE, Strange F, Burn F, et al. Hybrid operating room settings for treatment of complex dural arteriovenous fistulas. *World Neurosurg*. Dec 2018;120:e932-e939. PubMed

Tan HY, Yang J, Wang ZY, et al. Simultaneous supervision by microscope of endoscope-assisted microsurgery via presigmoid retrolabyrinthine approach: a pilot study. *Eur Ann Otorhinolaryngol Head Neck Dis*. Sep 2018;135(5S):S103-S106. PubMed

Tsuei YS, Liao CH, Lee CH, Liang YJ, Chen WH, Yang SF. Intraprocedural arterial perforation during neuroendovascular therapy: Preliminary result of a dual-trained endovascular neurosurgeon in the neurosurgical hybrid operating room. *J Chin Med Assoc*. 01 2018;81(1):31-36. PubMed

Wen CT, Liu YY, Fang HY, Hsieh MJ, Chao YK. Image-guided video-assisted thoracoscopic small lung tumor resection using near-infrared marking. *Surg Endosc*. 11 2018;32(11):4673-4680. PubMed

Review Articles

Byval'tsev, VA, Belykh EG, Kikuta K, Stepanov IA. A hybrid neurosurgical operating room: potentials in the treatment of arteriovenous malformations of the brain. *Biomed Eng*. 2018;52:14-18. https://link.springer.com/article/10.1007/s10527-018-9772-5