Editorial Commentary

The importance of understanding costs and cost-effectiveness in different surgical approaches for lung cancer resections

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We have read with great interest and appreciation the article authored by Heiden *et al.* (1). The study seeks to assess the cost-effectiveness and clinical benefits of the three modalities of lobectomy lung resection for lung cancer, including Robotic-assisted lobectomy (RAL), video-assisted thoracic surgery (VATS), and open lobectomy. They used decision tree modelling and outcomes data from previously published data. The authors focused on comparing the 'societal and healthcare benefits' of each procedural modality in regard to one another, exploring what factors drive RAL to be cost-effective, and determining the theoretical threshold of planned minimally invasive resections at which RAL becomes as cost-effective as VATS. Their key finding is that VATS is more cost-effective than RAL at lower "willingness to pay" thresholds. They cite a number of limitations and potential areas where RAL could be equivalent or superior to VATS in cost-effectiveness if certain thresholds are met. We applaud this effort to better understand the financial impact of minimally invasive surgery and specifically robotic assisted lobectomies but feel that the methodology used is hard to decipher and duplicate, and that the conclusions, while measured in deeper reading, superficially favor VATS without clear justification.

The Markov decision models generated to summarize the study design in *Fig.1A,1B* are routinely utilized in the field, but the authors fail to detail the parameters of each subgroup in the decision tree. Comparable studies (2,3), more clearly define each decision point and the inclusion criteria of each category they generate. In the absence of defined complications, the reader is left to incorporate their own clinical judgement into what complications ought to be included in such an analysis leading to a lack of clarity surrounding study design.

Tab.1 is a summative figure that includes the base case variables for the model inputs. It is nonintuitive in nature and leaves the reader with an undue burden to independently interpret the data displayed. Significant written clarification into the process of data generation, as seen in Chen *et al.* (2) and Kneuertz *et al.* (4) would vastly enhance reader understanding. Greater utilization of graphical representation of cost comparisons could advance clarity and understanding of the data presented. This table is the cornerstone of the findings presented in this manuscript, yet there is little information offered to the readers regarding how the data was generated, the significance of the values, and how readers should interpret the table.

It is unclear to us as to the validity of the quantitative data presented in *Tab.1*. The authors cite Simianu *et al.* (3)

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for the model input values for thoracotomy capital investment, VATS capital investment, cost of thoracotomy instruments, and the lifespan of RAL, VATS and thoracotomy equipment. Simianu's work evaluated the cost-effectiveness of laparoscopic versus robotic minimally invasive colectomy. The authors interchanged the cost of an open colectomy cited by Simianu with the cost of a thoracotomy. Furthermore, the authors utilize the cost of both VATS and RATS instruments per case in colectomies to be identical to those used for lobectomies. This assumption of equiveillance should have been discussed within the manuscript. These assumptions will significantly impact the findings of the sensitivity analysis. Regarding the Hospital Cost per day input. Heiden's input values do not match the data presented in the citation listed (5). These concerns do not change the validity of the methodology but do call into question the final results and the reader's ability to utilize the results in a meaningful way.

The primary objective of the manuscript was to evaluate and compare the cost effectiveness of RALS, VATS, and open thoracotomy from a societal and healthcare perspective. Consistent with existing literature, the authors concluded that VATS was the most cost-effective modality (2,4). Readers would have benefited from a more thorough elaboration on what variables were used in calculating the societal and healthcare costs. Throughout the manuscript these values are never explicitly defined making it challenging to fully comprehend the findings and implications of the sensitivity analysis. The actual differences noted were only 2% and 0.7% of the overall costs in the two methods. While statistically significant, is this meaningful enough to make a conclusion that VATS is more cost effective? The authors do later state that RAL is cost-competitive, but their conclusion in their abstract (which is what most people will read) does not address this.

Heiden *et al.* (1) offered many mechanisms through which RAL could decrease its associated costs including decreased robotic instrument costs, decreased quantity of instruments used per RAL, shorter length of hospital stays, lower complication rates, lower mortality rates, lower conversion rates, and higher hospital volume. While many of these proposed mechanisms would certainly lead to RAL becoming a more cost-effective lobectomy modality, many of these drivers of costs can be applied broadly to each of the other surgical modalities. For example, decreasing hospital length of stay would effectively drive down cost of all VATS, open thoracotomy, and RAL. However, decreasing complication rates and decreased operation time could feasibly drive down the cost of robotic procedures and are likely to happen with increasing surgeon proficiency. This discussion does give the reader options though for lowering the costs of any of their current surgical approaches.

Overall, Heiden *et al.* (1) do not sufficiently explain the methodology employed throughout this manuscript. The experimental design, data incorporated into their models, and the parameters of their sensitivity analysis are poorly characterized making it difficult to critically evaluate the validity, significance, and impact of this work. Equivocating the costs found in colectomies with the costs of lobectomies is a substantial extrapolation. These values play a critical role in the results of the sensitivity analysis and using them in their input model, without adequately addressing its appropriateness raises significant questions over the accuracy of the sensitivity analysis. We are excited by their interest in this work and feel that similar work could help guide surgeons and hospitals on how to strategize their lung cancer surgery programs, but without further information on the methods used by the authors, it is difficult to place these findings into the context of existing literature.

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Footnote

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Ethical Statement: The authors are accountable for all

aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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