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Pecuniary Inputs and their Applications to Intelligent Decision Making in Choice of Robotic and Conventional Surgeries in Gynecologic Oncology and Urology in A Private Sector Super Speciality Tertiary Care Hospital in Southern India.

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Abstract: Introduction: Robotic surgery is highlighted as a new medical technology that has the ability to standardize surgical techniques and make minimally invasive surgery possible**.** It is particularly suitable for complex procedures that require a high level of precision. There is a lot of promise for future advancements in the field of robotic surgery. The market for surgical robots was estimated at USD 4.4 billion globally in 2022, and it is anticipated to rise at a CAGR of 18 % from 2023 to 2030. This study involves the departments of gynecologic oncology and urology and intends to analyze the costs of both procedures- robotic surgery and traditional open surgery, in order to determine which procedure is more cost-effective. **Methods:** This is a retrospective study carried out in a 1400 bedded private hospital in South India. A sample size of 249 was obtained from the departments of gynecologic oncology and urology. Medical records of the patients aged above 18 years who underwent robotic surgery and conventional open surgery were obtained and analysed. **Results:** Out of the 249 patients, 55 patients were from Gynecologic oncology and 194 patients were from Urology. The Independent sample T test showed that the total cost for robotic surgery was significantly more (p-value<0.001) than the same for non-robotic surgery. The cost of medicines in robotic surgery was significantly more (p-value <0.001) than the same for non-robotic surgery. The cost of consumables for robotic surgery was significantly more (p-value <0.001) than the same for non-robotic surgery. The length of stay for robotic surgery was significantly more (p-value = 0.008) than the same for non-robotic surgery. **Discussion:** The study shows that even if robotic surgery cost significantly more than conventional surgery, it is safer and the length of stay is lesser than for conventional surgery, which results in better bed utilization. Robotic surgery also has better clinical outcomes and lesser pain and complications.

Keywords: *Robotic surgery, Cost, Gynecologic oncology, Urology*

1. Introduction:

Robot-assisted surgery, also known as robotic surgery, offers medical practitioners the ability to carry out a variety of intricate procedures with greater accuracy, flexibility and control as compared to traditional methods. Robotic surgery has been highlighted as a new medical technology that has the ability to standardize surgical techniques and make minimally invasive surgery possible. Surgery with a low degree of invasiveness may enhance patient outcomes while costing the health system lesser. Robotic surgery is a medical procedure that utilizes a robotic surgical system to operate on patients. It can either be performed on its own or in combination with open surgery, depending on the specific situation. This approach is similar to minimally invasive surgery.(1) The concept of remote surgery or tele-surgery was first investigated by the U.S. National Aeronautics and Space Administration (NASA) which was attracted by its possible applications for astronauts in orbit. The fundamental idea was to have a surgical tool machine aboard a space station that an earthbound surgeon might use to perform surgery. A similar plan was taken into consideration by the US Defence Advanced Research Projects Agency (DARPA). Researchers at DARPA tried to create remote tele-surgery equipment that would make it possible to operate on combat casualties.(2,3) Real advancement did not happen until the 2000s. In the 1980s, the first surgical procedures utilizing robotics were documented. Arthrobot, the first surgical robot was created to aid orthopedic procedures and was used for the first time in Vancouver, British Columbia, Canada in

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1983. This robot enables voice commands to be used to position and to move the patient's leg. The Da-Vinci system is currently the most widely used robotic surgical system. It was the first robotic surgery tool to gain FDA approval for use in laparoscopic procedures in 2000. The surgeon's console, a patient cart and a vision cart make up its three parts. Together these elements enable the surgeon to see what is happening and then to simulate the events to direct the tools.(4)

Robotic surgery is particularly suitable for complex procedures that require a high level of precision.(5) Sometimes the conventional method is not an option to perform exceedingly complicated surgical procedures. Robotic surgery may be the sole option in these circumstances. With the use of robotic surgery, surgeons may carefully inspect the area being treated and gain a clearer perspective. Despite all the benefits, all patients and conditions are not recommended for robotic surgery. Cardiology, Urology, Endocrinology, Gynecology, Otolaryngology, General medicine and colorectal surgery are among the medical specialties most frequently treated with robotic surgery equipment.(6,7) While robotic surgery may not be an option for everyone, it is recommended that the potential advantages and disadvantages be discussed before making a decision. There is a lot of promise for future advancements in the field of robotic surgery. Two particularly exciting breakthroughs that are anticipated are telemedicine and long-distance procedures.(8,9) With the aid of a robotic surgery system, a robot operated by a surgeon in one surgical centre will be able to operate on a patient in another surgical centre who is located in a different city, state or even continent. Although this is a surgical process that has been tried and tested and has been successfully completed, with faster internet and lower-cost bandwidths, it will soon be a simpler and more common practice.(5) The market for surgical robots was estimated at USD 4.4 billion globally in 2022, and it is anticipated to rise at a CAGR of 18 % from 2023 to 2030.(10) More than 6730 Da-Vinci surgical systems have been deployed in 69 nations as of the end of 2021 and more than 10 million minimally invasive robotic surgical procedures have been carried out including more than 1.5 million in 2021.(11,12) The surgical robotics market in India was estimated to be worth INR 7.02 billion in 2017 and is projected togrow at a CAGR of 19.80% between 2019 and 2024 to reach INR 26.01 billion. As of July 2019, there were 66 centers and 71 robotic installations. India has more than 500 skilled robotic surgeons. In these 12 years, robotic assistance has been used in over 12,800 surgeries.(7)

This study aims to compare the expenses associated with robotic surgery and traditional surgery. In the study, the term “traditional surgery” refers to an open surgery performed with a scalpel incision. This study involves a comparison of surgical procedures carried out with robotic technology versus those carried out via the traditional surgical approach. The focus is on similar procedures performed for comparable types of disorders with nearly equivalent levels of complications. The study was conducted at a private sector hospital in South India. Two departments from the same hospital were included in this study: Gynecologic oncology and Urology. In order to obtain a more accurate picture of the bed utilization rates for the various surgeries, this study takes into account additional variables such as the length of patient stay. Gynecologic oncology and Urology departments were selected for this study as they had the highest number of robotic surgeries in the hospital. The hospital performs between 270 and 280 robotic procedures on average each year. Twenty to twenty-five robotic surgeries are reported at the hospital each month. The facility offers robotic surgery in a variety of specialties including gynecology, urology, cardiology, general medicine, head & neck surgery and thoracic surgery.

2. Methodology:

Study Setting:

A retrospective study was carried out for six months from December 2022 to May 2023 in a 1400 bedded private tertiary care hospital in South India. The hospital is an established centre for robotic surgery training and has secured NABH and NABL accreditation.

Study Design:

Retrospective, single centric. Gynecologic oncology and Urology were the two hospital departments involved in the study. The sample size was 249. Medical records from patients who underwent robotic surgery and patients who received conventional open surgery were collected and analysed. The information was gathered on the surgeries carried out in 2022. Complete enumeration was done. Basic details like age, type of disease, net cost of the surgery and total length of stay of the patient were collected. Data regarding the expenses incurred on the procedures was acquired and studied in relation to robotic and non-robotic surgeries. General hospital costs of patients who underwent robotic surgery were compared with the same of those who underwent traditional open surgery. The total cost included the price of consumables, pharmaceutical goods and other charges. These prices were then broken down further to allow for individual cost comparisons for medicines and consumables.

Departments involved:

1. Gynecologic Oncology
2. Urology

3. Billing

4. Finance

5. Medical records

Inclusion criteria: Age above 18 years. Most popular surgeries in Gynecologic Oncology and Urology.

Sample size: The number of medical records that would be obtained for the study is anticipated to be 100.

Statistical method: Complete enumeration.

Tools used: MS Excel, Jamovi

3. Results:

This study included 249 patients who underwent robotic surgery and conventional open surgery with a mean age of 51.1 ±15.2 years. 55 patients were from Gynecologic Oncology and 194 patients were from Urology. Among the 55 patients from gynecologic oncology, 30 (54.55%) underwent robotic surgery and 25 (45.45%) patients underwent non-robotic surgery. Among the 194 patients from Urology, 97(50%) patients underwent robotic surgery and 97(50%) patients underwent non-robotic surgery.

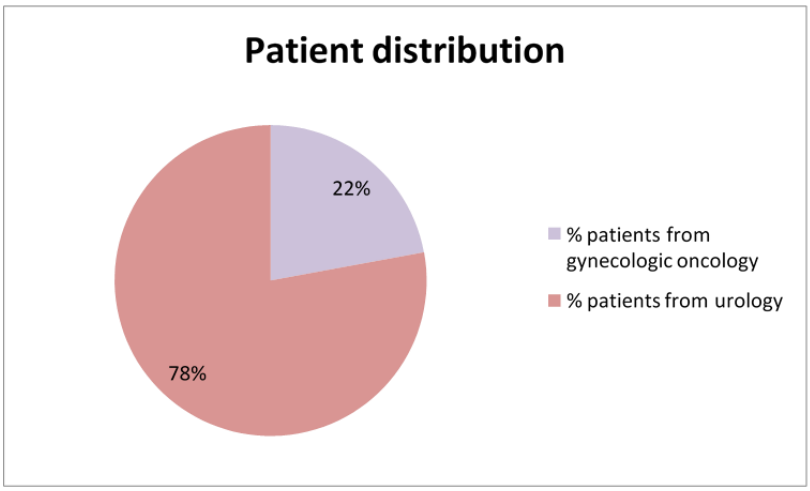

Fig 1. Patient distribution across departments: Gynecologic Oncology and Urology

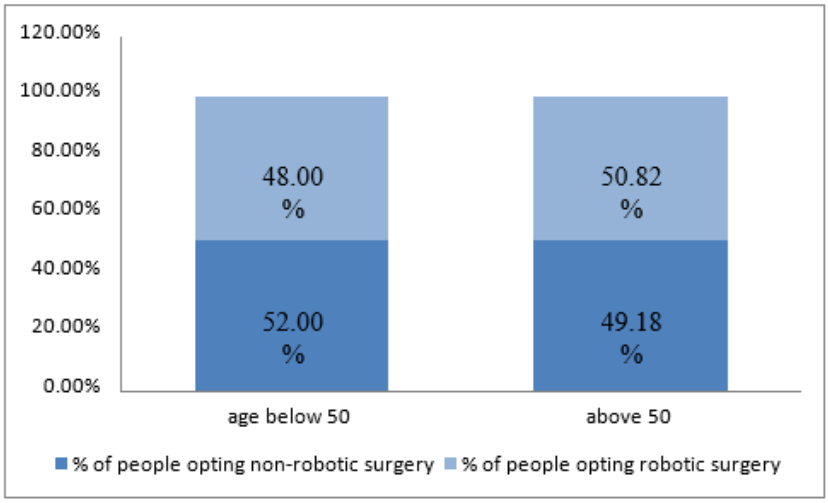

Fig 2. Percentage of patients opting for Robotic and Non-robotic surgery**.**

Table 1. Total hospital charges

Department	**Type of surgery**	**Total charges in INR (Mean ±SD)**
Gynecologic oncology	Robotic	317057 ±80618
	Non-robotic	62473 ±59134
Urology	Robotic	320865 ±94561
	Non-robotic	140334 ±17697

Table 1 shows that the total cost of surgery is significantly higher for robotic surgery than for Non-robotic surgery in both Gynecologic Oncology and Urology.

Table 2. Cost of medicines

Department	**Type of surgery**	**Cost of medicines in INR (Mean ±SD)**
Gynecologic oncology	Robotic	3801 ±998
	Non-robotic	1737 ±1221
Urology	Robotic	5092 ±1913
	Non-robotic	3230 ±672

Table 2 shows that the total cost of Medicines is significantly higher for robotic surgery than for Non-robotic surgery in both Gynecologic Oncology and Urology.

Table 3. Cost of consumables.

Department	**Type of surgery**	**Consumable cost in INR (Mean ± SD)**
Gynecologic oncology	Robotic	23356 ±45984
	Non-robotic	4502 ±4869
Urology	Robotic	24729 ±3068
	Non-robotic	12084 ±25965

Table 3 shows that the cost of consumables is significantly higher for robotic surgery than for Non-robotic surgery in both Gynecologic Oncology and Urology.

Table 4. Cost comparison table for patients who underwent robotic surgery and non-robotic surgery

Parameters	**Robotic surgery (Mean ±SD)**	**Non-robotic surgery (Mean ±SD)**	**p-value**
Total cost	319965.44±91165.88	124379.06±91165.88	<0.001
Medicinal cost	4787.17±1822.33	2995.99±948.25	<0.001
Consumables	24404.93±31633	10897.15±4372.04	<0.001
Length of stay	4.17±1.60	4.62±2.35	0.008

The Independent samples T-test was used to compare the parameters between robotic surgery and non- robotic surgery. The result showed that the total cost for robotic surgery is significantly higher (p-value <0.001) than the total cost for non-robotic surgery. The cost of medicines in robotic surgery is significantly higher (p-value <0.001) than the cost of medicines in non-robotic surgery. The cost of consumables in robotic surgery is significantly higher (p-value <0.001) than the cost of consumables in non-robotic surgery. There is no significant difference in the length of stay of patients who underwent robotic surgery and patients who underwent non-robotic surgery.

4. Discussion:

The findings in the current study are similar to the findings by Tedesco et al where the cost of robotic surgery was higher than the cost of non-robotic surgery, yet robotic surgery was not adopted by the hospital. Studies have recorded the following advantages which include: Greater precision, better visualization, smaller incisions, lower risk, shorter length of stay in the hospital, lesser

pain, lesser blood loss, faster recovery times, minimal scarring, lower expenditure on post operative care. Despite all these benefits, non-robotic traditional open surgeries are indicated when surgeons need better access to the operating area and when clinical conditions are a contraindication for robotic surgery.(13,14,15) The disadvantages of robotic surgery include a large initial investment, recurring cost of consumables, high cost of maintenance and a higher set-up time for the surgical robots and the operating rooms.(16,17) Disadvantages of non-robotic surgery include an increased length of stay in hospital, longer recovery times, more pain, higher risks of complications such as bleeding and infection and larger scars.(18,19)

Strosberg et al found that robotic cholecystectomy is safer and more expensive than laparoscopic cholecystectomy.(12) Ahmed et al found that robotic surgery is more expensive than both laparoscopic surgery and traditional open surgery; robotic surgery and laparoscopic surgery have similar postoperative outcomes; robotic surgery has shorter hospital stay (median = 1.5 days) and lower blood loss (227-237 ml). Going forward, there is a strong possibility of a fall in the cost of robotic surgery with increasing competition and dissemination of technology.(13) Ayesha et al found that robotic surgery was more expensive than laparoscopic surgery regardless of the procedure. When compared to laparoscopic procedures, robotic procedures showed a 2.2% reduction in complications and a 0.7 day decrement in the length of stay. The study was unable to shed light on the cost effectiveness of robotic surgery.(13,14)

Tedesco et al recommended against the introduction of robotic surgery as they found out that the number of surgeries required for break even was unreasonably high. Also, the price points that needed to be operational to achieve financial break even were also too high to be sustainable in the long run. This meant that laparoscopic surgery and conventional surgery remained attractive alternatives as the current operational and financial fundamentals of robotic surgery did not allow it to challenge them.(8) The current study shows that robotic surgery is more expensive than non-robotic surgery; it is cost-effective as it is safer than non robotic surgery with a shorter length of stay. Robotic surgery also has better clinical outcomes. The challenges to adopt robotic surgery are high capital and maintenance costs. The current study shows that robotic surgery is more expensive than non-robotic surgery regardless of the type of surgery. There is significant scope for further research on this topic. Possible themes include analysis of operating times, manpower, cost of manpower and equipment cost across robotic and non robotic surgeries.

References:

[1] Morrell ALG, Morrell-Junior AC, Morrell AG, Mendes JMF, Tustumi F, De-Oliveira-e-silva LG, et al. The history ofrobotic surgery and its evolution: when illusion becomes reality. Rev Col Bras Cir [Internet]. 2021 [cited 2023 Apr 28];48:1–9. Available from: https://pubmed.ncbi.nlm.nih.gov/33470371/

[2] George EI, Brand TC, LaPorta A, Marescaux J, Satava RM. Origins of Robotic Surgery: From Skepticism to Standard of Care. JSLS [Internet]. 2018 Oct 1 [cited 2023 Apr 28];22(4). Available from:

[3] /pmc/articles/PMC6261744/

[4] Kim YT, Kim SW, Jung YW. Robotic Surgery in Gynecologic Field. Yonsei Med J [Internet]. 2008 Dec 31 [cited2023 Apr 28];49(6):886–90. Available from: https://doi.org/10.3349/ymj.2008.49.6.886

[5] Secretariat MA. Robotic-Assisted Minimally Invasive Surgery for Gynecologic and Urologic Oncology: An Evidence-Based Analysis. Ont Health Technol Assess Ser [Internet]. 2010 [cited 2023 Apr 28];10(27):1. Available from: /pmc/articles/PMC3382308/

[6] Leal Ghezzi T, Campos Corleta O. 30 Years of Robotic Surgery. World J Surg [Internet]. 2016 Oct 1 [cited 2023 Apr 28];40(10):2550–7. Available from: https://pubmed.ncbi.nlm.nih.gov/27177648/

[7] Xue R, Liu R. Statistical analysis of da Vinci procedure volumes of 2021 in the Chinese Mainland. IntelligentSurgery. 2022 Sep 1;4:18–22.

[8] Bora GS, Narain TA, Sharma AP, Mavuduru RS, Devana SK, Singh SK, et al. Robot-assisted surgery in India: ASWOT analysis. Indian J Urol [Internet]. 2020 Jan 1 [cited 2023 May 11];36(1):1. Available from: /pmc/articles/PMC6961426/

[9] Tedesco G, Faggiano FC, Leo E, Derrico P, Ritrovato M. A comparative cost analysis of robotic-assisted surgery versus laparoscopic surgery and open surgery: the necessity of investing knowledgeably. SurgEndosc [Internet]. 2016Nov 1 [cited 2023 May 28];30(11):5044–51. Available from: https://pubmed.ncbi.nlm.nih.gov/26983435/

[10] Hyams E, Pierorazio P, Mullins JK, Ward M, Allaf M. A comparative cost analysis of robot-assisted versus traditional laparoscopic partial nephrectomy. J Endourol [Internet]. 2012 Jul 1 [cited 2023 May 28];26(7):843–7. Available from: https://pubmed.ncbi.nlm.nih.gov/22204599/

[11] Ielpo B, Podda M, Burdio F, Sanchez-Velazquez P,

Guerrero MA, Nuñez J, et al. Cost-Effectiveness of Robotic vs. Laparoscopic Surgery for Different Surgical Procedures: Protocol for a Prospective, Multicentric Study (ROBOCOSTES). Front Surg [Internet]. 2022 May 6 [cited 2023 May 28];9. Available from: https://pubmed.ncbi.nlm.nih.gov/36227017/

[12] De Pastena M, Esposito A, Paiella S, Surci N, Montagnini G, Marchegiani G, et al. Cost-effectiveness and quality of life analysis of laparoscopic and robotic distal pancreatectomy: a propensity score-matched study. SurgEndosc [Internet]. 2021 Mar 1 [cited 2023 May 28];35(3):1420–8. Available from: https://pubmed.ncbi.nlm.nih.gov/32240383/

[13] Strosberg DS, Nguyen MC, Muscarella P, Narula VK. A retrospective comparison of robotic cholecystectomy versus laparoscopic cholecystectomy: operative outcomes and cost analysis. SurgEndosc [Internet]. 2017 Mar 1 [cited 2023 May 28];31(3):1436–41. Available from: https://pubmed.ncbi.nlm.nih.gov/27495346/

[14] Ahmed K, Ibrahim A, Wang TT, Khan N, Challacombe B, Khan MS, et al. Assessing the cost effectiveness of robotics in urological surgery - a systematic review. BJU Int [Internet]. 2012 Nov [cited 2023 May 28];110(10):1544–

[15] 56. Available from: https://pubmed.ncbi.nlm.nih.gov/22443296/

[16] Ng AP, Sanaiha Y, Bakhtiyar SS, Ebrahimian S, Branche C, Benharash P. National analysis of cost disparities in robotic-assisted versus laparoscopic abdominal operations. Surgery [Internet]. 2023 Jun 1 [cited 2023 May 28];173(6). Available from: https://pubmed.ncbi.nlm.nih.gov/36959072/

[17] Hibner, M., Marianowski, P., Szymusik, I., &Wielgós, M. (2012). Zastosowanierobotów w chirurgiiginekologicznej [Robotic surgery in gynecology]. *Ginekologiapolska*, *83*(12), 934–938.

[18] Ilic, D., Evans, S. M., Allan, C. A., Jung, J. H., Murphy, D., & Frydenberg, M. (2017). Laparoscopic and robotic- assisted versus open radical prostatectomy for the treatment of localised prostate cancer. *The Cochrane database of systematic reviews*, *9*(9), CD009625. https://doi.org/10.1002/14651858.CD009625.pub2

[19] Hockstein, N. G., Gourin, C. G., Faust, R. A., &Terris, D. J. (2007). A history of robots: from science fiction tosurgical robotics. *Journal of robotic surgery*, *1*(2), 113–118. https://doi.org/10.1007/s11701-007-0021-2

[20] Evans, C. R., Medina, M. G., & Dwyer, A. M. (2018). Telemedicine and telerobotics: from science fiction to reality.

[21] *Updates in surgery*, *70*(3), 357–362. https://doi.org/10.1007/s13304-018-0574-9

[22] Davies, B. L., Hibberd, R. D., Ng, W. S., Timoney, A. G., & Wickham, J. E. (1991). The development of a surgeonrobot for prostatectomies. *Proceedings of the Institution of* Mechanical *Engineers. Part H, Journal of engineering inmedicine*, *205*(1), 35–38. https://doi.org/10.1243/PIME_PROC_1991_205_259_02

[23] Mr. Kaustubh Patil, Promod Kakade. (2014). Self-Sustained Debacle Repression Using Zig-Bee Communication. International Journal of New Practices in Management and Engineering, 3(04), 05 - 10. Retrieved from http://ijnpme.org/index.php/IJNPME/article/view/32

[24] Sherje, D. N. . (2021). Content Based Image Retrieval Based on Feature Extraction and Classification Using Deep Learning Techniques. Research Journal of Computer Systems and Engineering, 2(1), 16:22. Retrieved from https://technicaljournals.org/RJCSE/index.php/journal/article/view/14