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Implementing an AI-powered endoscopic surgery video recording system in a large hospital network: lessons learned and future prospects

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Abstract

Aim: Traditional methods of evaluating surgical performance, such as self-assessment and peer review, are limited by bias and inconsistency. Recent advances in artificial intelligence (AI) have introduced novel tools for objective evaluation of surgical techniques. This study reports the implementation of an AI-powered video management system across four surgical centers and its impact on the documentation, analysis, and standardization of minimally invasive surgeries (MIS).

Methods: A retrospective analysis was conducted of all MIS procedures performed at four centers within Assuta Medical Centers between July 2023 and June 2024. The AI system (Theator™, Inc.) is integrated with endoscopic cameras to automatically document, store, and analyze surgeries in real time, focusing on key intraoperative steps. Performance metrics, including the achievement of key surgical steps, were recorded. Rates of surgeon engagement in self-assessment and postoperative reviews were also evaluated.

Results: A total of 11,080 MIS procedures were performed, with 96.7% (10,725) documented by the AI system. The most frequently performed procedures were laparoscopic inguinal hernia repair (36.6%), gastric bypass (22.7%), and cholecystectomy (19.9%). The Critical View of Safety (CVS) was achieved in 60.6% of cholecystectomies, with inter-center variability ranging from 14% to 70%. Surgeon self-assessment was conducted



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in 22.2% of documented cases.

Conclusion: The implementation of an AI-powered video management system facilitated comprehensive surgical documentation and analysis, supporting both the standardization of surgical key steps and surgeon self-assessment. This system holds promise for improving surgical performance and safety through enhanced feedback and data-driven practice improvements.

Keywords: Artificial intelligence (AI), video management, minimally invasive surgery (MIS), self-assessment, surgical key steps

INTRODUCTION

Surgical expertise evolves through extensive practice under the mentorship of seasoned surgeons, with ongoing refinement throughout a surgeon's career^[1]. Efforts to enhance surgical practice for improved patient outcomes and safety traditionally rely on personal experience, direct observation, peer feedback, and patient outcomes. However, these approaches have notable limitations as self-assessment is susceptible to bias, peer feedback is often intermittent and unavailable during critical moments, and patient outcomes, while reflective of overall care, do not specifically evaluate technical proficiency^[2,3].

In the ongoing quest to enhance surgical outcomes and safety, the surgical community actively explores objective and standardized tools to improve surgical quality^[4]. Various tools have been proposed, including observational checklists, direct peer assessments, and video recordings reviewed by experienced surgeons^[5,6]. However, many of these tools are primarily designed to evaluate the skills and competence of surgical trainees, with only a few aimed at providing feedback and assistance to practicing surgeons^[3,7]. Additionally, the widespread adoption of these tools has been limited by the additional attention they require and the lack of user-friendliness in existing platforms^[6]. An alternative approach to enhancing surgical quality and safety involves the implementation of standardized key steps throughout the surgical procedure, often termed "evidence-based practices". Notable examples include the Critical View of Safety (CVS) in cholecystectomy and the Critical View of the Myopectineal Orifice (CVMO) in inguinal hernia repair^[8,9]. However, it remains challenging to ascertain whether surgeons accurately and consistently adopt these practices outside of small clinical trials^[10].

Recent advancements in image recognition and artificial intelligence (AI) have demonstrated significant efficacy in assessing surgical practices^[11,12]. AI-enabled devices offer real-time analysis during surgeries, providing immediate feedback and facilitating comprehensive postoperative reviews^[13]. This technological capability opens new avenues for detailed performance evaluations and continuous professional development. The Theator™ (Theator Inc., Palo Alto, CA) platform, an AI-powered video management system, was implemented at Assuta Medical Centers in Israel. This system captures, stores, and analyzes surgical videos to deliver real-time analytical insights and support extensive post-surgical investigations. This study explores the integration of this system and its impact on surgical proficiency and surgeon conduct within our facilities.

METHODS

This study encompasses all cases of abdominal and pelvic minimally invasive surgery (MIS) performed across four centers of the Assuta Medical Corporation, as identified through our institutional platform database from June 2023 to July 2024.

Assuta Medical Corporation, comprising four general centers and seven outpatient centers, operates as a non-government organization, annually conducting over 100,000 surgeries and treating more than 1.5 million patients. Operating solely as private practice facilities, surgeries are exclusively performed by senior surgeons. From July 2022 to January 2023, Assuta Corporation implemented a surgical AI platform (Theator Inc., Palo Alto, CA) across its centers. This platform integrates with MIS and endoscopic cameras, automatically documenting all procedures and requiring explicit action to halt recording. Confidentiality of patient and staff data is maintained through an algorithm that obscures extra-cavitary images until the camera enters the body cavity.

The platform systematically captures, securely stores, and integrates visual AI analytics of procedural videos during and post-surgery. Relying on proprietary video recognition algorithms, it segments videos temporally into key procedural steps and pinpoints critical intraoperative actions and events. During cholecystectomy, for instance, it recognizes key steps such as clearing the hepatocystic triangle of fat and fibrous tissue, dissecting Calot's triangle, achieving the CVS before dividing cystic structures, performing a methodical time-out before dividing cystic structures, separating the gallbladder from the liver, and extracting the gallbladder using a protective bag. In addition to individual procedure analysis for personalized feedback, comprehensive analyses across multiple surgeries can discern overarching clinical trends for guiding strategic clinical leadership decisions. [Figure 1](#) shows the platform interface.

As detailed in prior publications^[14,15], the platform's learning process is based on both human and machine learning, using original datasets that are variable in terms of patient characteristics, medical centers, and additional factors. Visual cues agreed upon by expert surgeons are the basis for AI identification of surgical steps and events. Initially, clinicians annotated procedural phases and key steps to facilitate machine learning. Subsequently, the system refines itself through the analysis of numerous surgeries, identifying and annotating key steps. These annotations are then validated by expert clinicians, who approve or refine the system's notifications. This iterative process ensures ongoing enhancement of the platform's precision and efficacy.

For clarity and consistency in data reporting, we have designated Tel Aviv Assuta Medical Center as "Center A", Haifa Assuta Medical Center as "Center B", Rishon LeTsiyon Assuta Medical Center as "Center C", and Be'er Sheva Assuta Medical Center as "Center D".

RESULTS

Between July 2023 and June 2024, a total of 11,080 MIS were performed across the four centers. Center A accounted for 4,579 cases (41%), followed by Center B with 3,054 cases (27.6%), Center C with 2,065 cases (18.6%), and Center D with 1,382 cases (12.5%). Of these, 10,725 MIS procedures (96.7%) were documented and analyzed by the platform. Center D had the highest documentation rate at 97.2% (1,348 cases), followed by Center B at 97.1% (2,969 cases), Center C at 96.9% (2,003 cases), and Center A at 96.1% (4,405 cases), as detailed in [Table 1](#).

[Table 2](#) outlines the distribution of MIS documented by the platform. Inguinal hernia repair was the most frequently recorded procedure, with 3,923 cases (36.6%), followed by 2,434 (22.7%) gastric bypass surgeries and 2,136 cholecystectomies (19.9%).

[Table 3](#) details the select key steps identified by the platform for the surgeries detailed in [Table 2](#). Among the 3,923 inguinal hernia repairs documented, complete cord skeletonization was performed to ensure total hernia sac reduction in 1,395 cases (35.6%). Of the 2,434 gastric bypass procedures recorded, an anastomotic

Table 1. Minimally invasive surgeries performed from July 2023 to June 2024

Surgeries performed	Center A	Center B	Center C	Center D	Total
Total surgeries	4,579	3,054	2,065	1,382	11,080
Surgeries documented by the platform N (%)	4,405 (96.1%)	2,969 (97.1%)	2,003 (96.9%)	1,348 (97.2%)	10,725 (96.7%)

Table 2. Surgical procedure documented by the platform

Surgical procedure (N = 10,725)	Center A	Center B	Center C	Center D	Total
Inguinal hernia repair	1,726 (16.1%)	958 (8.9%)	723 (6.7%)	516 (4.8%)	3,923 (36.6%)
Gastric bypass	654 (6.1%)	1,016 (9.5%)	529 (4.9%)	235 (2.2%)	2,434 (22.7%)
Cholecystectomy	919 (8.6%)	571 (5.3%)	360 (3.4%)	286 (2.7%)	2,136 (19.9%)
Umbilical hernia repair	333 (3.1%)	152 (1.4%)	190 (1.8%)	139 (1.3%)	814 (7.6%)
Non umbilical ventral hernia repair	196 (1.8%)	104 (1%)	100 (0.9%)	105 (1%)	505 (4.7%)
Sleeve gastrectomy	156 (1.5%)	87 (0.8%)	43 (0.4%)	2 (0.02%)	288 (2.7%)
Left colectomy/sigmoidectomy	116 (1.1%)	22 (0.2%)	13 (0.1%)	25 (0.2%)	176 (1.6%)
Hiatal hernia	110 (1%)	23 (0.2%)	22 (0.2%)	26 (0.2%)	181 (1.7%)
Right colectomy	69 (0.6%)	16 (0.1%)	12 (0.1%)	11 (0.1%)	108 (1%)
Proctectomy	40 (0.4%)	14 (0.1%)	14 (0.1%)	8 (0.1%)	76 (0.7%)
Adrenalectomy	20 (0.2%)	8 (0.1%)	–	8 (0.1%)	36 (0.3%)
Whipple procedure/Distal pancreatectomy	26 (0.2%)	–	–	–	26 (0.2%)
Gastrectomy/Partial gastrectomy	22 (0.2%)	–	–	–	22 (0.2%)

Table 3. Select key steps identified by the platform

Surgical procedure	Key step	Number of identifications	Percentage of identifications
Inguinal hernia repair	Complete cord skeletonization	1,395/3,923	35.6%
Gastric bypass	Anastomotic leak test	2,252/2,434	92.5%
Cholecystectomy	CVS achievement	1,294/2,136	60.6%
Umbilical hernia repair	Fascial closure	333/814	40.9%
Non umbilical ventral hernia repair	Fascial closure	232/505	45.9%
Sleeve gastrectomy	Gastric transection begins at least 2 cm from the pylorus	272/288	94.4%
Left colectomy/sigmoidectomy	Anastomotic leak test	149/176	84.7%
Right colectomy	Duodenal visualization	89/108	82.4%
Proctectomy	Anastomotic leak test	56/76	73.7%

leak test was conducted in 2,252 cases (92.5%). For the 2,136 cholecystectomies performed, the CVS was attained in 1,295 cases (60.6%).

A variation in the achievement of the CVS during cholecystectomy was observed across all centers throughout the study period, with rates ranging from 31% to 68% at Center A, 17% to 57% at Center B, 28% to 68% at Center C, and 14% to 70% at Center D. Additionally, discrepancies in the achievement of the CVS were noted between the centers, as detailed in [Table 4](#). The mean achievement of the CVS was highest at Center A (52%), compared to Center C (47%), Center D (38%), and Center B (36%), as illustrated in [Figure 2](#). Notably, no surgeries were performed at Centers C and D during October and November 2023 due to non-medical factors.

Table 4. Achievement of a critical view of safety by centers

	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Mean
Center A	55%	52%	31%	39%	46%	37%	53%	66%	59%	57%	51%	68%	52%
Center B	35%	17%	27%	24%	26%	25%	44%	45%	34%	57%	54%	37%	36%
Center C	39%	28%	32%	-	36%	48%	44%	66%	54%	68%	52%	52%	47%
Center D	21%	14%	22%	-	50%	30%	29%	39%	45%	38%	70%	50%	38%

Of the 10,725 MISs documented and analyzed by the platform, 2,382 surgeries (22.2%) were reviewed by surgeons for self-debriefing.

DISCUSSION

The integration of an AI-driven platform across four centers has provided valuable insights into the consistency and quality of minimally invasive surgeries. This study demonstrates the platform's capability to systematically document and analyze a vast majority (96.7%) of the surgeries performed, demonstrating its ability to capture and analyze a diverse range of surgical interventions. Notably, 22.2% of the documented procedures were subsequently reviewed by the operating surgeons for self-debriefing, highlighting the platform's utility in enhancing postoperative assessment and continuous surgical improvement.

An essential contribution of this platform is its ability to accurately identify and assess intraoperative critical key steps, offering an objective measure of surgical quality. Ortenzi *et al.* demonstrated that the platform achieved an overall accuracy of 88.8% in identifying six key steps during TEP procedures, as validated against those labeled by a trained team across 619 cases^[16]. Similarly, Khanna *et al.* reported an accuracy of 92.8% for the platform when assessing 474 robotic-assisted radical prostatectomies, with results compared to manually annotated key steps^[17]. Additional studies further corroborate the platform's reliability: in transurethral resection of bladder tumor (TURBT) surgeries, the platform achieved an accuracy of 89.6% for identifying three key steps, and in laparoscopic hysterectomy, it reached an accuracy of 93.1% in key step identification^[18,19]. These findings collectively reinforce the platform's precision and reliability in surgical analysis.

Our findings revealed disparities in the performance of specific key steps, such as the complete cord skeletonization during inguinal hernia repair and the anastomotic leak test during gastric bypass. These findings highlight areas where further surgical training or process optimization may be required to ensure consistency and adherence to best practices. Moreover, our study identified a mean achievement rate of 60.6% for the CVS during cholecystectomy, with considerable variability observed both across and within centers during the study period. This variability, ranging from 14% to 70%, underscores the necessity for targeted interventions to standardize surgical practices and enhance outcomes across institutions. In a recent prospective multicenter study, Fried *et al.* examined CVS adoption rates in laparoscopic cholecystectomy following a quality initiative using the described platform^[20]. The study initially assessed baseline CVS achievement, surgery duration, complexity, and adverse events across two centers. Following the implementation of a quality initiative aimed at

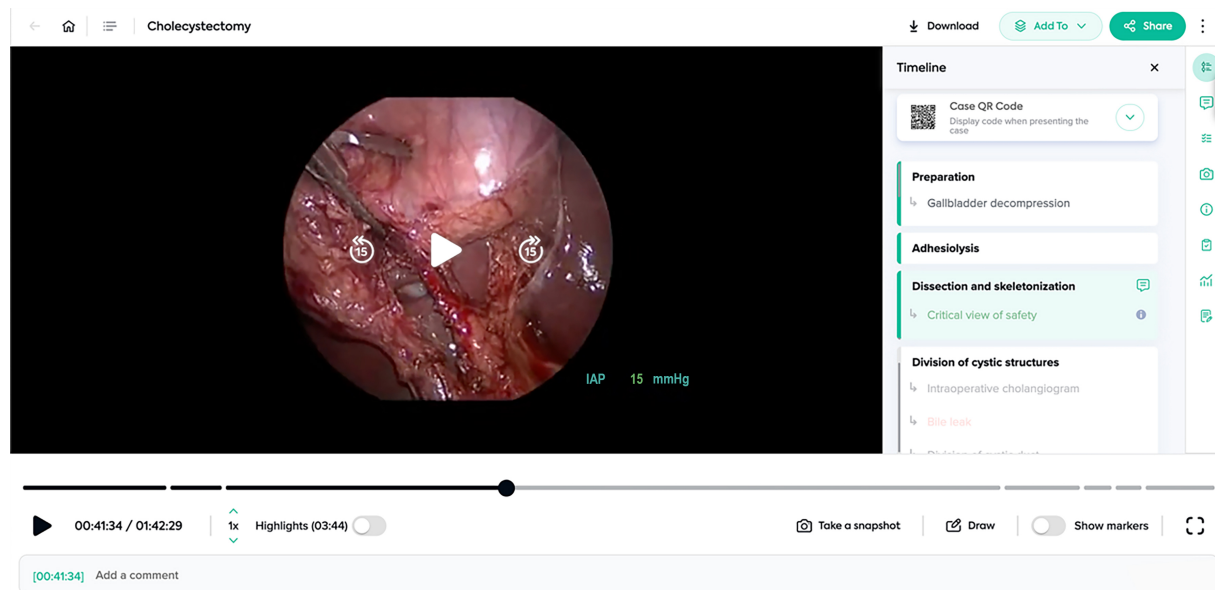


Figure 1. Critical view of safety in a laparoscopic cholecystectomy as viewed in the Theator Inc. platform.

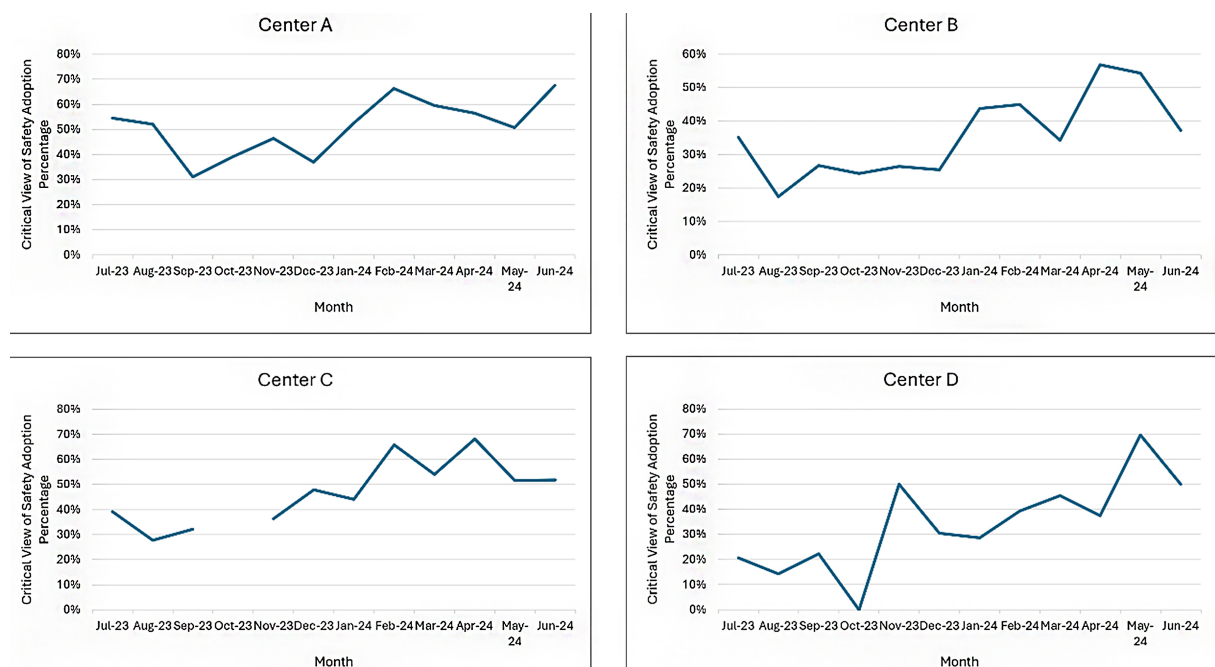


Figure 2. Critical view of safety achievement in cholecystectomy across centers.

achieving a 75% CVS adoption rate, the study found a significant increase in adoption, from 39.2% in the three months prior to the intervention to 69.2% in the final three months ($P < .001$), with monthly adoption rates increasing from 33.3% to 75.7%. These findings underscore that achieving surgical data benchmarks can lead to measurable improvements in surgical practice and safety. By overcoming the challenges of data collection, new opportunities for targeted improvement interventions become more accessible and impactful.

Furthermore, the platform's contribution to surgeon self-assessment and ongoing professional development is noteworthy. The observation that 22.2% of documented surgeries were reviewed by operating surgeons for self-debriefing underscores the necessity of systems that provide easy access to surgical data and support the ongoing refinement of surgical practice. We attribute this relatively high rate of self-debriefing to the platform's user-friendly interface and its accessibility from any computer or smartphone, facilitating timely and effective reviews.

It is essential to address the challenges associated with the implementation of such a platform. Given the ongoing legal pressures faced by surgeons, there are valid concerns that this system could be misused as a tool for unjustly critiquing surgical performance, potentially leading to legal repercussions^[21-23]. Acknowledging this limitation, we strongly advocate for the development of robust regulatory frameworks designed to protect surgeons from potential misuse of the platform. This could be achieved through national regulations that classify the data generated by the platform as privileged and confidential, with its use strictly confined to educational and quality improvement purposes. By creating a legal and professional environment where the focus remains on using those systems for constructive feedback and advancement, rather than punitive measures, we can ensure that this innovative technology achieves its full potential in advancing surgical care.

This study has several limitations. First, as a retrospective, non-comparative analysis, it provides a snapshot of multiple surgeries without the depth of detail that might be achieved in a more focused investigation. Additionally, the observational nature of this study precludes establishing a direct causal relationship between the use of the AI platforms and the observed improvements in surgical outcomes, such as the increased adoption of the CVS. While positive trends were noted, it is uncertain how much of these can be directly attributed to the platform, as other concurrent initiatives or external influences may have played a role. However, it is important to emphasize that the primary objective of this study was to report our experience with this specific platform rather than to draw definitive causal conclusions. Second, our findings are derived from data collected shortly after the platform's implementation, which may not reflect long-term usage patterns. The surgeon's engagement with the platform could evolve over time, potentially affecting its utility and impact. Third, this study was conducted within a single healthcare system where surgeries are exclusively performed by experienced surgeons. As such, the findings may not be generalizable to other settings, such as academic centers where attending surgeons are continuously teaching residents, or to different communities of surgeons, such as residents in training.

In conclusion, the implementation of an AI-powered video management system across four centers has offered significant insights into surgeon performance across diverse procedures. The system has demonstrated its efficacy in systematically documenting and analyzing a substantial volume of surgeries, allowing for a broad evaluation of surgical trends and a detailed review of individual cases. By capturing surgical key steps, the platform shows promise in promoting the standardization of techniques. Additionally, by facilitating self-assessment and peer review, it presents new opportunities for refining surgical practice and improving overall performance.

DECLARATIONS

Authors' contributions

Material preparation and data collection: Szold A, Messer N

Manuscript writing: Messer N, Szold A

Manuscript review and revision: Messer N, Nizri E, Lahat G, Szold A

Study supervision: Szold A

All authors read and approved the final manuscript.

All authors contributed to the study's conception and design.

Availability of data and materials

Aggregated or de-identified data are available upon reasonable request, subject to institutional and privacy constraints.

Financial support and sponsorship

None.

Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

After consultation with the Assuta Hospital IRB committee, it was concluded that this study did not require formal approval. We analyzed only general, non-identifiable data, and no specific patient data were evaluated. We had requested a representative patient image from the vendor. However, we did not have the patient's identity and cannot obtain consent. Therefore, we removed this image from the manuscript to ensure compliance with privacy guidelines.

Consent for publication

Not applicable.

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