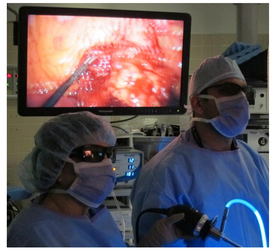
Compromised Robotic Surgical Visualization: Archaic Issues in a Modern Operating Room

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Introduction

While Robotic-Assisted Surgery (RAS) has been revolutionizing surgical procedures and continuing to grow, it has various areas needing improvement, especially the visualization sector. [1] Suboptimal vision due to lens occlusions, an issue prevalent in both laparoscopic and robotic surgery, has been a topic of concern in laparoscopic surgery but has not received attention in RAS.



Picture adapted from generalsurgeons.ca [2]

Research Goal

This study explores the existing shortcomings of RAS vision, specifically exploring and quantifying the degree of disruption encountered due to poor robotic visualization at a major academic institution.



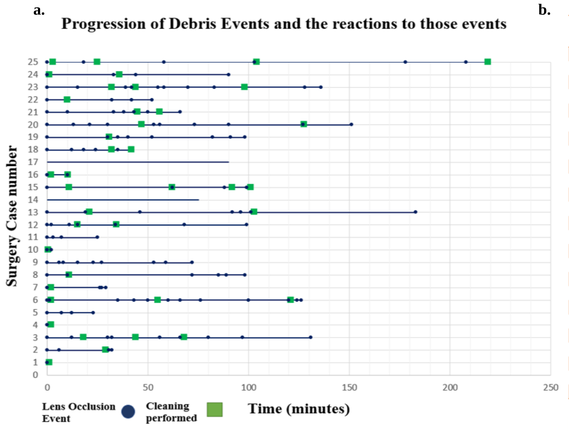
Picture adapted from davincisurgery.com [3]

Methods

Across 25 RAS procedures, of various specialties, metrics regarding visual clarity from the bedside monitor display were tracked such as **(i)** Total operative time spent under clear vision, suboptimal vision and cleaning time **(ii)** Number of cleaning events **(iii)** Number of lens occlusion (debris) events **(iv)** Reaction/decision of clinicians in response to a lens occlusions event **(v)** Cause of lens occlusion **(vi)** Location distribution of debris across the monitor. Debris events were defined as a discernible distortion observed on the lens. Start time was recorded as the time of the first appearance of a debris event. In total 32.5 hours of RAS observation time was recorded.

Results

a.



b.

Case number	Clear vision	Suboptimal Vision (min)	Total Time (min)
25	122	97	219
24	37.0	53.0	90.0
23	48.0	88.0	136
22	12.0	30.0	42.0
21	15.0	51.0	66.0
20	29.5	122	151
19	4.00	94.0	98.0
18	3.00	39.0	42.0
17	90.0	0.00	90.0
16	8.00	2.37	10.4
15	84.0	17.0	101
14	75.0	0.00	75.0
13	105	78.0	183
12	52.6	46.4	99.0
11	0.00	25.0	25.0
10	1.50	0.50	2.00
9	0.00	72.0	72.0
8	61.0	37.0	98.0
7	24.0	5.00	29.0
6	41.0	85.0	126
5	0.00	23.0	23.0
4	0.00	7.00	7.00
3	36.0	95.0	131
2	1.50	30.5	32.0
1	0.00	1.00	1.00
Average	34.0	43.9	77.9
St. Dev.	36.2	36.8	57.0

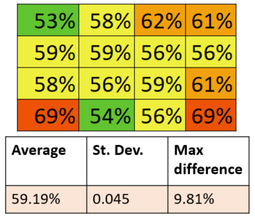
Fig. 1 (a) Progression of debris events in vision in 25 cases over time **(b)** Metrics of the quality of surgical vision across 25 cases.

Per Case Analysis	Suboptimal Vision (minutes)	Number of Debris Events
Mean	43.9	5.20
St. Dev	36.8	3.29
Minimum	0.00	0.00
Maximum	122	12.0

Table 1 Metrics regarding time spent working under suboptimal vision time and debris events in each case across 25 cases.

	Minimum	Maximum	Mean	St. Dev.
Per case (minutes)	0.50	3.00	1.28	0.82
Per cleaning event (minutes)	0.33	1.00	0.58	0.19

Table 2 Metrics regarding cleaning time of the scope considering both individual cleaning events and case totals



Average	St. Dev.	Max difference
59.19%	0.045	9.81%

Fig. 2 Heatmap of the distribution of debris on the monitor display divided into 16 squares

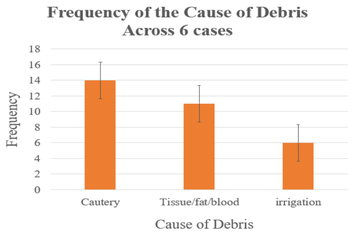


Fig. 3 Histogram of the debris causing agents

Discussion

From the 25 case observations, it can be seen that:

- 56.4% of the total observation time was spent under compromised visualization, suggesting lens obscuration is a substantial problem
- The progression chart in Figure 1 shows that 108 (83%) of events were not cleaned within two minutes of being encountered.
- In only 2 (8%) of the cases, 100% of the observation time was spent under clear vision and no debris events occurred.
- Across 10 cases, average cleaning time was 1.275 minutes, making up 1.5% of the entire observation time. (Figure 2)
- From Figure 3, cautery appears to be the most frequent (45%) cause of debris accumulation on scope.

Lens occlusions serve as interruptions and disruptions to surgical flow worsening surgeons' mental focus and increasing their decision fatigue. [4]

In this study, there were a few limitations including the low volume of cases, being a single institution study, the heterogeneity of the cases; the heterogeneity led to a more robust sample set.

Conclusion

This study demonstrates that it is concerning and clinically relevant that surgeons are performing complex minimally invasive surgery with a compromised visual field consistently across surgical specialties, calling attention to the cumbersome process of the RAS scope. Future work will include analyzing effects of experience level of the OR personnel and the severity of debris on willingness to clean. Clinical and monetary impacts of compromised visualization will be assessed.

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