Original Article

Three-Dimensional Versus Two-Dimensional Laparoscopic Salpingectomy in Patients with Hydrosalpinx Undergoing IVF-ET. A Randomized Controlled Trial Conducted in Egypt

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ABSTRACT

Objectives: Our study aimed to compare the operative outcomes of laparoscopic salpingectomy operations conducted using 3-D and standard 2-D laparoscopic vision systems to determine which is better during surgery.

Patients and Methods: This prospective, parallel two-arm single-blinded allocation-concealed randomized controlled trial was conducted at the Obstetrics and Gynecology Department, Cairo University, Egypt. We randomized 36 patients in a 1:1 ratio to the 3-D or 2-D laparoscopy groups. In the 3-D laparoscopy group, salpingectomy was performed using the Storz Image1 S 3-D laparoscopy system. In the 2-D laparoscopy group, salpingectomy was performed using conventional 2-D laparoscopy. At the end of the operation, we recorded the time needed to excise the hydrosalpinx, the total operative time, the estimated intraoperative blood loss, and the surgeon's comfort.

Results: When comparing the intraoperative findings of the 3-D and 2-D groups, we found a lower operative time (*p-value* = 0019), less time for fallopian tube excision (*p-value* < 0.001), and higher comfort of the surgeon (*p-value* =<0.0001) in the 3-D group than in the 2-D group. On the other hand, we found no statistically significant difference between the groups in the amount of blood lost during surgery detected by delta hemoglobin (*p-value* = 0.413).

Conclusion: 3-D laparoscopy is very helpful and shortens surgical time, thereby reducing cost, exposure to anesthetic agents, and morbidity, thus improving the quality of care provided to the patient.

Key Words: 2D Laparoscopy, 3D Laparoscopy, hydrosalpinx, infertility, in *vitro* fertilization.

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INTRODUCTION

Tubal factors are responsible for approximately 25% of infertility cases, and the most serious manifestation of tubal disease is hydrosalpinx. Hydrosalpinx is a distension or dilatation of the fallopian tube in the presence of a distal tubal occlusion[1]. The success of ART for patients with hydrosalpinx tubal disease is reduced by 50% compared with women who do not have hydrosalpinx. A Cochrane review showed that laparoscopic salpingectomy or tubal disconnection before IVF improves the chances of success[1].

Over the last twenty years, minimally invasive surgery has become very popular and has become the standard procedure to treat gynecologic diseases. There is much evidence that shows that laparoscopic surgery has many benefits compared to laparotomy, including decreased pain sensation after surgery, faster discharge from the hospital, better recovery after surgery, better cosmetic outcomes, fewer wound-related complications, and a lower cost[2]. Recent data suggest that up to 80% of gynecologic surgeries can be accomplished laparoscopically[3].

Laparoscopic salpingectomy could be performed by either a 2-D or 3-D laparoscopic system. The 2-D laparoscopic system only has one camera (monoscopic), which results in a loss of depth perception[4]. Loss of depth of perception could lead to spatial disorientation, a higher mental load, and visual fatigue, considering monocular vision on a flat screen[5].

However, stereooscopic 3-D laparoscopy uses two cameras that are placed next to one another. Images from these two distinct cameras are sent through glasses that have a separate lens for each camera. In the end, the photos are combined and filtered, increasing the depth of perception. Increased depth of perception is associated with better accuracy and faster performance, as well as a faster learning curve[4]. In addition, in a clinical setting, 3D vision would lead to significantly faster operating times, reduced amount of bleeding during surgery, and shorter hospital stays, probably because of its ability to improve short- and long-term outcomes[5]. The disadvantages of 3D laparoscopy include cognitive workload and adverse effects such as headaches, blurred vision, vertigo, and dizziness. Knowledge of intricate surgical tasks and the

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update in technology in the meanings of novel 3D-vision systems prevents adverse effects and leads to a better cognitive workload in favor of 3D-vision[5].

No blind randomized studies have been conducted to compare operator performance between 3-D and 2-D laparoscopy. Our study aim was to compare the operative outcomes of laparoscopic salpingectomy operations conducted using 3-D and standard 2-D laparoscopic vision systems to determine which is better during surgery.

PATIENTS AND METHODS

This prospective, parallel two-arm, single-blinded allocation-concealed randomized controlled trial was conducted at the Obstetrics and Gynecology Department, Cairo University, Egypt, between April 2022 and December 2022.

The inclusion criteria included patients with unilateral hydrosalpinx diagnosed with hysterosalpingography or laparoscopy undergoing laparoscopic salpingectomy before IVF-ET and with a body mass index (BMI) less than 40.

The exclusion criteria included patients with coexistent adnexal pathology, extensive pelvic adhesions, coagulation defects, and cardiac or chest diseases. Our study was open-label due to the surgical nature of the treatment.

Thirty-six patients were randomized in a 1:1 proportion to the 3-D laparoscopy group or the 2-D laparoscopy group using computer-generated random numbers concealed in successively numbered opaque sealed envelopes. The study nurse opened envelopes consecutively in the theatre before the beginning of the operation to allocate patients to the assigned group. The patients were not aware of the treatment they were receiving general anesthesia was given to all patients before the surgery was performed by the senior author, the head of the minimally invasive surgery department with more than ten years of experience in laparoscopic surgery. In the 3-D laparoscopy group, salpingectomy was carried out using the Storz Image 1 S 3-D laparoscopy system (Karl Storz, Tuttlingen, Germany), which comprised a 10 mm scope with two full H-D sensors at its tip, and a 3-D control unit plus a 3-D display. Surgeons wear special 3-D polarization glasses. In the 2-D laparoscopy group, salpingectomy was performed using a conventional 2-D laparoscopy system. In both groups, bipolar electrocoagulation was used to coagulate the mesosalpinx to the fallopian tube whenever possible to avoid ovarian blood supply compromise. At the end of the operation, we recorded the time needed to excise the hydrosalpinx (the time needed to remove the hydrosalpinx from the surrounding structures), total operative time (time between the first skin incision and the removal of trocars), amount of bleeding during surgery (the difference in the preoperative and postoperative hemoglobin), and comfort of the surgeon, which was evaluated using a visual analog scale ranging from 0 (least comfortable) to 10 (most comfortable).

The primary outcome was the time needed to excise the hydrosalpinx, and the secondary outcomes were the total operative time, the surgeon's comfort, and the estimated bleeding during surgery to determine which is better during surgery Figures 1,2,3,4).

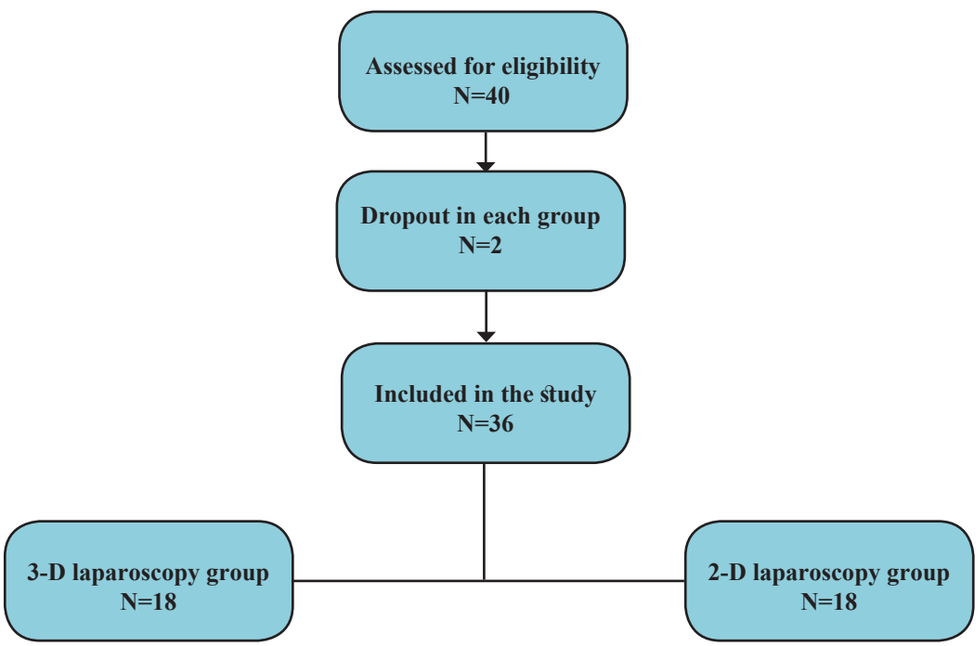

Fig. 1: Consort flow-chart of the cases

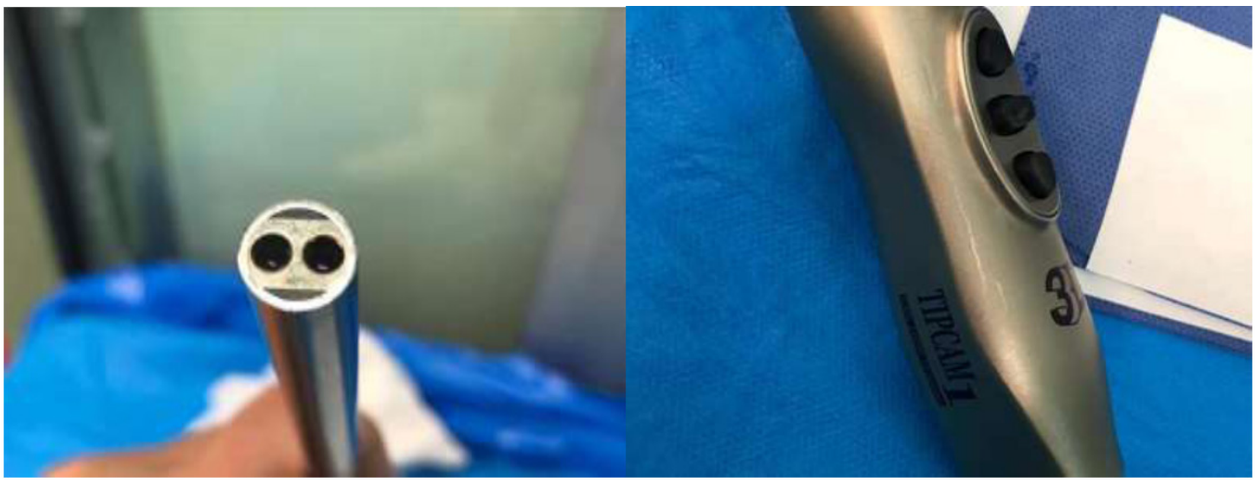

Fig. 2: 3D camera head with the telescope in Storz image 1 S 3D laparoscopy system (Karl Storz, Tuttlingen, Germany) at Kasr Al Ainy Obstetrics and Gynecology Theater

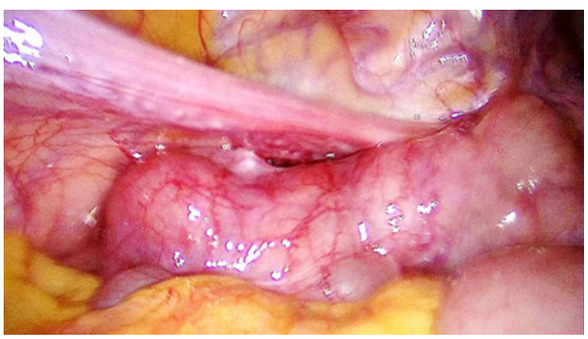

Fig. 3: Fallopian tube with Hydrosalpinix, a real photo from the study at Kasr Al Ainy Obstetrics and Gynecology Theater

Fig. 4: Laparoscopic salpingectomy, a real photo from the study at Kasr Al Ainy Obstetrics and Gynecology Theater

Sample size calculation

To date, no studies in the literature have reported the time needed to excise the hydrosalpinx by 2-D or 3-D laparoscopy. We reviewed video recordings of the last thirty 2-D laparoscopic salpingectomy procedures performed at our institution by the investigators (AEM and UF) to calculate the time needed to excise the hydrosalpinx. The (mean ± SD) time needed to excise the hydrosalpinx was 10.33 ± 3.11 minutes. We considered a 30% decrease in the time needed to excise the hydrosalpinx in favor of 3-D laparoscopy to represent a clinically significant difference, and to detect this difference between the two groups, sixteen patients were included in each study arm to achieve 80% study power at a significance level of 0.05 (as measured at https://www.sealedenvelope.com/power/continuous-superiority). To account for a 10% noncompletion rate, the total sample size was 36.

Statistical analysis

We used Student's t test to compare quantitative data between the research groups. Using the chi-square test, categorical data were compared. Yates' correction equation was used instead when the expected frequency was 5. A *p-value* of 50.05 was considered statistically significant. We used Microsoft Excel version 7 (Microsoft Corporation, NY, USA) and SPSS (Statistical Package for the Social Sciences; SPSS Inc., Chicago, IL, USA), a statistical tool for Microsoft Windows for all statistical calculations.

RESULTS

During the study period, 36 patients who underwent IVF with unilateral hydrosalpinges were enrolled. Overall, 18 patients were scheduled for 3-dimensional laparoscopic salpingectomy (3-D group); the other 18 underwent 2-dimensional laparoscopic salpingectomy (2-D group).

The two groups were comparable regarding age, BMI, infertility type and duration, gravidity, and parity (Table 1).

The time needed for fallopian tube excision and the total operative time were significantly lower in the 3-D group (*P-values* of 0.019 and 0.001, respectively), and the surgeon's comfort was significantly increased in the 3-D group (*P value* 0.001). On the other hand, there was no significant difference in bleeding during surgery between the two studied groups (*P value* of 0.413) (Table 2).

Table 1: Patients' characteristics

	2D Group (n=18)	3D Group (n= 18)	*P value*
Age	29.44 ± 5.61	29.44±5.61	0.839
Gravidity	1.33±2.22	1.33±2.17	1
Parity	0.5 ± 0.924	0.556± 0.922	0.858
BMI	30.13± 5.24	29.64± 5.42	0.787
Duration of infertility (years)	4.53± 3.57	4.42± 3.43	0.925
Type of infertility			
• 1^{ry} infertility	9/18(50%)	9/18(50%)	1
• 2^{ry} infertility	9/18(50%)	9/18(50%)	1

Values are expressed as mean± SD or n/n (%).

Table 2: Operative details

	2D Group (n=18)	3D Group (n= 18)	*P value*
Duration of operation (sec)	1959 ± 622	1454 ±610	0.019
Time needed to excise hydrosalpinx (sec)	463 ±160	266 ± 105	<0.001
Comfort of surgeon	4.94 ± 1.67	8.39 ± 1.38	<0.001
Delta Hg	0.57 ± 0.24	0.49 ± 0.319	0.413

Value is expressed as mean± SD.

DISCUSSION

Laparotomy is rarely performed for gynecologic surgery, except in gynecologic oncology. Although minimally invasive surgery is advantageous, it may be challenging for both expert and novice surgeons because of the lack of depth perception and spatial disorientation. The mental load resulting from this, and visual fatigue are further challenges[5].

Independent of the surgeon's experience level, 3D laparoscopy leads to time acceleration, increased accuracy, and a lower rate of errors in simulated settings[6]. The reported increased cognitive workload and adverse effects such as headache, blurred vision, vertigo, and dizziness with the 3D-vision system were attributed to the lack of surgical knowledge of the participants in the studies[7].

The authors of another study also concluded that these unfavorable results reported mainly in older studies might be due to using old vision systems for 3D laparoscopy that differ from novel 3D-HD systems[5].

We showed in our study that the time for fallopian tube excision and the total surgical time were significantly lower in the 3-D group than in the 2-D group, while the surgeon's comfort was significantly higher in the 3-D group. However, we found no significant difference between the two groups regarding intraoperative blood loss.

The results reported by our study are comparable to those reported in a recent study that included 158 patients allocated to two groups comparing 2-D and 3-D laparoscopic surgery (cholecystectomy and appendectomy). The surgeon's comfort was significantly higher in the 3-D group than in the 2-D group (mean 2-D vs. 3-D: 5.1 versus 5.6; $p = 0.0318$). Unexpectedly, we found no significant differences between the 2-D and 3-D groups regarding the total operative time in all the procedures included (mean time 2-D versus 3-D; Mann–Whitney U test, 50.3 vs. 50.4 min; $P > 0.2$), and these results disagree with our results[8].

A study was carried out between November 2014 and December 2015 to compare the outcomes of total laparoscopic hysterectomy (TLH) with 3-D versus traditional 2-D laparoscopy. A 3-D laparoscopic system (3-D-TLH) was used to perform 47 TLH procedures, and the outcomes were compared to those of TLH performed using the traditional 2-D laparoscopic system (2-D-TLH) performed just before the start of using the 3-D laparoscopic system. The mean operative time was significantly lower in the 3-D group than in the 2-D group. No statistically significant difference was found when comparing bleeding during surgery in either group (*p-value* of 0.642)[9], and these results agree with our results.

In contrast to our study, Zheng and his colleagues reported that when comparing 3-D versus 2-D laparoscopic gastrectomy, we found no significant differences between the two groups regarding the total operative time (3-D versus 2-D, 17635 min vs. 17433 min, p=0.562). Regarding intraoperative blood loss, there was a significant reduction in the 3-D group versus the 2-D group (6183 ml vs. 82119 min, $p = 0.045$)[10], and these results disagree with our results.

The results reported by our study are comparable to those reported in a recent meta-analysis that included 12 studies involving 1456 patients (3-D group 683

patients and 2-D group 773 patients); this meta-analysis compared short-term surgical outcomes between 3-D and 2-D laparoscopic surgery for gastrointestinal cancer patients. In this analysis, the mean surgical time in the 3-D group was significantly faster than that in the 2-D group (WMD, 9.08; 95% CI, 14.77, 3.40; $P = 0.002$) and this result is consistent with our results. They also reported a significantly decreased amount of bleeding during surgery in the 3-D group compared to the 2-D group, disagreeing with our results. (WMD: 13.60, 95% confidence interval: 21.48, 5.72; $P = 0.001$)[11].

In 2020, a study was conducted on 120 patients with colon adenocarcinoma. On the day of surgery, the patients were randomly chosen by a computer to undergo laparoscopic surgery by the use of either a 3D-HD display or a 2D-HD imaging system. A total of 60 patients underwent laparoscopic colon resection with a 3D-HD laparoscope (3-D group), while another 60 underwent 2D-HD laparoscopy (2-D group). This study showed a significantly shorter total operative time in the 3-D group than in the 2-D group (123.2±34.2 min vs. 142.2±23.5 min, $P = 0.018$). On the other hand, there was an insignificant difference between the groups regarding the amount of bleeding during surgery ($P > 0.05$)[12], and these results agree with our results.

The results reported by our study are comparable to those reported in a recent meta-analysis that included 258 patients undergoing minimally invasive right colectomy for cancer. Of these, 163 patients fulfilled the inclusion criteria. One hundred-eleven were operated with a 2D system and 52 were operated using a 3D system. The mean operative time was 185.3 ± 48.6 min in the 2D group and 169.8 ± 32.4 in the 3D laparoscopic group. The difference was almost statistically significant ($P = 0.087$). The mean anastomotic time was 19.3 ± 2.9 min in the 2D group, and 16.9 ± 2.3 min in the 3D group ($P < 0.001$)[13].

In 2023, a systematic review and meta-analysis were conducted on 689 patients who were suffering from gastric cancer, with 348 (50.5%) in the 3D group and 341 (49.5%) in the 2D group. 3D laparoscopic gastrectomy reduces the operative time (WMD − 28.57 min, 95% CI − 50.70 to − 6.44, $p = 0.011$), and this result is consistent with ours. 3D laparoscopic gastrectomy was associated with less bleeding during surgery (WMD − 6.69 mL, 95% CI − 8.09 to − 5.29, $p < 0.001$), while our study showed no significant difference in bleeding during surgery between the 3-D and 2-D groups[14].

To the best of our knowledge, this is the first randomized controlled trial to compare 3D versus 2D laparoscopic salpingectomy. The main strength of our study is that it is a randomized control design; however, the main limitation is the small sample size.

CONCLUSION

In conclusion, 3-D laparoscopy statistically limits the time needed for performing salpingectomy and total operative time, and it makes it more comfortable for the surgeon compared to 2-D laparoscopy, so 3-D laparoscopy is very helpful and shortens the surgical time, thereby reducing cost, exposure to anesthetic agents, and morbidity, thus improving the quality of care provided to the patient.

ABBREVIATIONS

2-D: Two-Dimensional; **2D-HD:** Two-Dimensional High Definition; **3-D:** Three-Dimensional; **3D-HD:** Two-Dimensional High Definition; **BMI:** Body Mass Index; **IVF-ET:** In-*vitro* fertilization embryo transfer; **TLH:** total laparoscopic hysterectomy.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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