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Conventional 3-port vs. single-incision laparoscopic oophorectomy for ovarian cryopreservation in paediatric surgery: a retrospective case-note review

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Abstract

Objective: We aim to compare conventional 3-port with single-incision laparoscopic surgery (SILS) for oophorectomy in patients undergoing ovarian cryopreservation.

Background: Demand for cryopreservation of ovarian tissue prior to the initiation of gonadotoxic treatment has risen significantly since its introduction in England in 2013. Traditionally, laparoscopic oophorectomy is performed using a 3-port technique with an umbilical port and 2 smaller 5-mm working ports. Energy devices can be used to allow haemostatic dissection of the ovary and this is delivered through the umbilical port site. In an attempt to improve efficiency, post-operative outcomes, and enhance cosmesis; our department initiated the use of the Applied Medical GelPoint Mini Advanced Access Platform single port technique using a vertical trans-umbilical approach for ovarian cryopreservation.

Methods: All patients undergoing laparoscopic oophorectomy for cryopreservation between September 2013 and August 2017 were included. The patients were consented for SILS, 3-port and open oophorectomies. All patients received maximum local anaesthetic wound infiltration intra-operatively. Case notes and theatre electronic data were reviewed and data was collected on additional procedure, conversion rate, operative time, post-operative analgesia requirement, complications and length of hospital stay.

Results: A total of 106 patients underwent laparoscopic oophorectomy during the study period. Of these, 40 underwent conventional 3-port, 65 had SILS and 1 patient had open. No cases were converted from the intended method. There was a statistically significant difference in the mean operative time; with SILS being faster than the conventional 3-port method (SILS: 40.4 min; 3-port: 51.7 min; $p = 0.017$). There was no difference in length of stay or perioperative analgesics, and complication rates in both groups were low. Informal qualitative feedback included surgeons stating that the ovary was much easier to deliver using the SILS technique. Patients were also happy with a single cosmetically appeasing scar hidden within the umbilicus.

Conclusion: SILS is an acceptable technique in ovarian cryopreservation allowing a quicker operative time, easier delivery of the ovary, and better cosmesis. A learning curve is recognised due to the ergonomics of single port laparoscopy; however, the technique can be established easily in departments with existing laparoscopic capabilities. This is the first paper which establishes this within a Paediatric Surgical setting, and adult literature suggests that further

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prospective trials may prove some benefit in ovarian tissue volume or time to initiation of treatment due to enhanced recovery.

Keywords: Cryopreservation, Ovary, Single-incision laparoscopy, Surgery, Oncology

Background

The cryopreservation of gonadal tissue to preserve fertility for those undergoing gonadotoxic treatments such as chemotherapy with alkylating agents, pelvic or total body irradiation and high dose chemotherapy prior to bone marrow transplantation has proven successful in both adults and children [1, 2]. Bone marrow transplantation is now successfully curing both malignant and several non-malignant haematological conditions such as thalassaemia and sickle cell anaemia. The cytotoxic side effects of these treatments are known to have a profound effect on fertility. Survival rates for children and young adults with cancer now exceed 80%, and therefore, an increasing number are being referred for cryopreservation of their gonadal tissue to provide them with a chance of fertility in their future adult lives.

Laparoscopic unilateral oophorectomy is the preferred method for retrieving ovarian tissue in pre-and peripubertal girls [3]. The Oxford Reproductive Tissue Cryopreservation programme is one of a small number of centres licensed to carry out these procedures. Retrieval of gonadal tissue is often performed with required concurrent procedures to minimise anaesthetic exposure and volume of procedures. These concurrent procedures commonly include placement of central venous access, bone marrow aspirate or trephine, lumbar puncture or gastrostomy insertion. Increasingly, patients are safely achieving day case admissions for this service.

Conventional 3-port laparoscopy has been long favoured over open approaches for benign ovarian pathology. This approach, using a standard 10-mm umbilical port and two 5-mm working ports, was utilised safely in girls to remove a single healthy ovary, allowing oocyte retrieval and cryopreservation of the ovarian tissue. Experienced surgeons at our centre began to perform this procedure using the conventional technique; however, they found that safe delivery of the ovary with minimal trauma was essential to minimise loss of ovarian tissue. Even in young girls, surgeons needed to extend the umbilical fascial incision prior to delivery which often risked injury to the specimen. Furthermore, much of the time performing this procedure was spent in placing and closing the port sites, as well as in extending the umbilical incision to allow unhindered delivery of the ovary. Single-incision laparoscopy (SILS) requires a z-shaped umbilical skin incision and a larger fascial opening to accommodate the camera and working instruments. It has been demonstrated to be a feasible and safe technique in adult ovarian surgery [4]. The time required to safely place this port is not felt to be greater than that required for a standard umbilical port and the delivery of the ovary is felt to be simpler with this method. We hypothesised that single-incision laparoscopy would not be inferior to and may be superior to conventional 3-port laparoscopy in oophorectomy for cryopreservation purposes.

Material and methods

A retrospective review of all girls undergoing unilateral laparoscopic oophorectomy for cryopreservation of gonadal tissue was performed. This included all cases since the service was introduced in September 2013 to August 2017. In June 2016, following a period of training in our departmental laparoscopic training facility, we introduced the SILS technique and a change in practice was established. The GelPOINT Mini Advanced Access Platform is a single port consisting of a GelSeal Cap, Alexis Wound Retractor and is supplied with 3 10-mm Sleeves, 1 12-mm Sleeve and an introducer. These allow instrumentation with 5–12-mm instruments. The GelSeal Cap contains a securing device to the Alexis Wound Retractor and two attachments for CO_2 insufflation tubing. It freely rotates upon the Alexis Wound Retractor, thus allowing optimum port positioning. During the study, the traditional 'z' type umbilical incision for SILS was also replaced by a vertical trans-umbilical approach.

Inclusion criteria were any patient aged between 2 and 18 years old who underwent oophorectomy for cryopreservation by either conventional 3-port laparoscopy or SILS technique. At our institution, we utilise the age of 2 years as a cut off for SILS. This is surgeon preference and the reason is purely due to size of the child and intra-abdominal space. Cases were all performed with our institution by a consultant surgeon or by a senior registrar with consultant assistance.

Informed consent was taken for each patient undergoing surgery. The initial patients were consented for only conventional 3-port or conversion to open procedure. Following training in the local laparoscopic suite; SILS was introduced (2016). All patients from this time were fully informed of the alternate method and consented for SILS, conventional 3-port, and conversion to open procedure. No patients declined SILS approach. The consent also included the removal and storage of human tissue by a specialist consultant from the cryopreservation team.

Operative technique

The patient undergoes general anaesthetic induction and is placed in the supine position within the theatre. For conventional 3-port technique, a 10 mm umbilical port is inserted under direct vision and pneumoperitoneum is achieved. A 10 mm 30° scope is inserted. Two further 5-mm working ports are inserted on the left and right flanks at the level of the umbilicus under direct scope visualisation. For the SILS technique, the umbilicus is everted and a vertical trans-umbilical incision is made. Further dissection is performed and an opening of minimum diameter 15 mm is made at the fascial level. The Alexis wound guard component of the GelPoint is then inserted and applied ensuring no bowel is trapped between the internal flange and anterior abdominal wall. The GelPoint is then constructed (see Fig. 1) and applied onto the external flange allowing pneumoperitoneum to be established. Laparoscopy is performed to ensure and confirm the presence of ovaries bilaterally. Clinical photographs are taken for the patient record. For selection, we prefer ovaries which are disease free and larger. Often, the right ovary is easier to remove given its location away from the sigmoid colon. However, both techniques allow ease of access to either side.

An atraumatic grasper is used to provide countertraction whilst the Ligasure is used to dissect at the interface between the ovary and the fimbriae of the fallopian tube (see Fig. 2). Once the ovary is free, in the conventional 3-point technique, it is placed in an extraction bag. This often requires widening of the umbilical incision at the fascial level to deliver the ovary safely. For SILS technique, the ovary is simply gently held and extracted through the umbilical incision after disconnection of the GelPoint from the external flange. A cryopreservation team is present within the theatre to allow immediately processing and timely storage of the sample. The Alexis wound guard component is then removed for closure. Closure of all sites is performed using absorbable sutures for the fascia and subcutaneous tissue and skin glue for both techniques.

Outcome measures were assessed through analysis of patient and operating theatre records. Data parameters collected included the initial operative approach, conversion to an alternative approach, operative time,

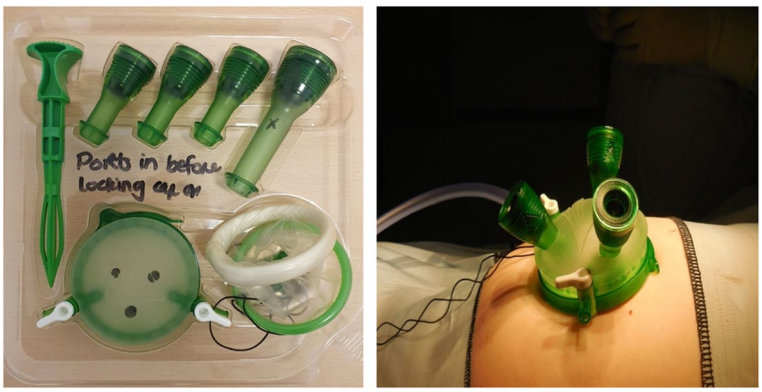

Fig. 1 GelPoint port in situ with pneumoperitoneum established

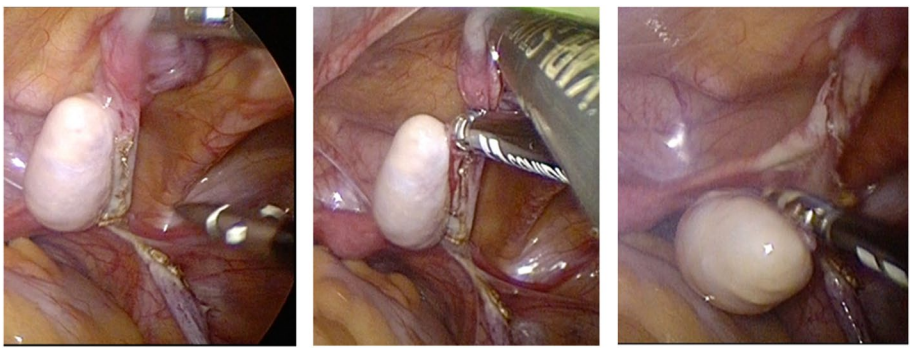

Fig. 2 SILS dissection—note the 'crossover' of instruments with the Ligasure appearing on the left of the screen but held in the surgeon's right hand

concurrent surgical procedures, post-operative analgesia requirement, length of hospital stay, intra-operative complications or post-operative complications within 30 days of surgery. Patients who underwent concurrent procedures were excluded from the operative time calculations. For analysis, patients were grouped as conventional 3-port vs. SILS, and a two sampled *t*-test assuming unequal variances was used to assess differences in the outcomes.

All patients received maximal doses of local anaesthetic infiltration to the wound site intra-operatively. Post-operative analgesia requirements were assessed for children who had electronic prescription records (April 2015 onwards). This assessment included reviewing the electronic drug chart for the total number of doses of paracetamol, non-steroidal anti-inflammatory drug (NSAID) or opiates (as morphine equivalent doses). Those without electronic records were excluded from this area of analysis. For the purpose of analgesic requirements, patients were assessed in two groups; those performed as day case surgery and those who remained in hospital overnight. This was to ensure comparison of like for like when assessing the impact of the surgical technique in analgesic usage. Pain scores were not formally assessed or investigated in this study. Patients were reviewed post-operatively by the surgeon, anaesthetist and specialist oncology consultant from the cryopreservation team.

Ethical committee approval was not required for this retrospective case note review.

Results

A total of 106 patients underwent laparoscopic oophorectomy during the study period. Of these, 40 underwent conventional 3-port, 65 had SILS and 1 patient had open. No cases were converted from the intended method. The patient who underwent an open ovarian cryopreservation had this alongside tumour nephrectomy and was therefore excluded from the data analysis for SILS vs. conventional 3-port laparoscopies. Sixty-four out of 106 patients (60.4%) underwent concurrent procedures as demonstrated in Table 1. Many patients underwent multiple procedures in conjunction with the oophorectomy as required on a case-by-case analysis, most commonly insertion of central venous line plus bone marrow trephine.

No significant differences in age were identified between the two groups: those undergoing conventional 3-port laparoscopy compared to those undergoing SILS. The mean age of patients undergoing conventional 3-port technique was 11.4 years vs. 9.8 years for SILS technique. No significant difference was noted in the age of the patients as this was a retrospective review following a change in practice. The only complication occurred in 1 patient within the 3-port technique group who developed an umbilical haematoma. This did not require any further treatment.

Table 1 Concurrent procedures performed alongside oophorectomy for cryopreservation

Concurrent procedure performed	Number of patients
Insertion of central venous catheter	61
Bone marrow trephine	8
Additional biopsy	3
Bronchioalveolar lavage	2
Gastrostomy insertion	1
Tumour nephrectomy	1

Operative time was assessed for those patients' undergoing cryopreservation as a sole procedure. Conventional 3-port technique ($n=16$) had a mean operating time of 51.7 min (range 37–88). SILS ($n=25$) mean operating time was 40.4 min (range 15–82). Assuming a significant p-value to be <0.05, a two sampled t-test assuming unequal variances showed this difference was significant $p(T<=t)=0.017$.

Maximum inpatient stay recorded for a conventional 3-port technique was 32 days vs. 35 days for SILS. Both of these were due to complications from underlying malignancy and ongoing chemotherapy and not attributable to the surgical procedure or technique. No difference in length of stay between the two groups was observed.

Not all patients were included in analysis for analgesic requirements as electronic prescription records were not available for patients operated on before April 2015. The analgesia used by one patient undergoing the SILS technique was not recorded. Therefore, 88 patients (83%) were included in analysis of post-operative analgesia requirements (conventional 3-port $n=24$, SILS $n=64$). Using a two sampled t-test assuming unequal variances in both groups ($p=$ day case/overnight), no significant difference between the number of doses of paracetamol ($p=0.71/0.44$), NSAIDs ($p=0.91/0.25$) or opiates ($p=0.11/0.24$) in either of the groups was found. The number of patients receiving patient or nurse controlled analgesic pumps (PCA/NCAs) was also comparable with 54.2% ($n=13$) in the conventional 3-port group vs. 45.3% ($n=29$) in the SILS group (see Figs. 3 and 4).

During the change from conventional 3-port laparoscopy to SILS, there were some anecdotal observations by the 2 consultant surgeons who changed to the SILS technique. The first was comments regarding cosmesis

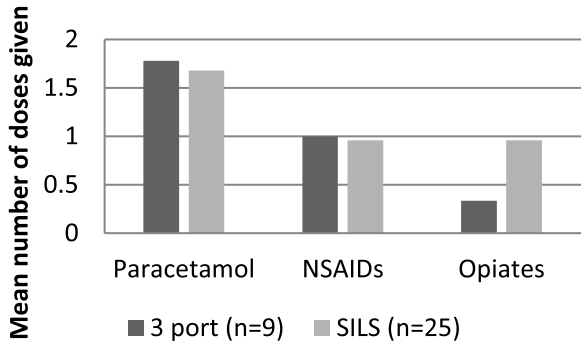

Fig. 3 Post-operative analgesia requirement for day case procedure

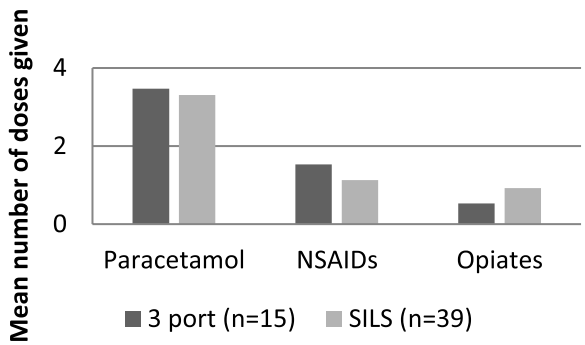

Fig. 4 Post-operative analgesia requirement for overnight stay (24 h postoperatively)

from the parents of children and the patients who underwent the SILS technique prompting the clinical photographs (see Fig. 5) to evidence the scar or lack. Furthermore, the laboratory also commented on the improved quality of ovarian tissue they were receiving with the SILS technique, and the theatre staff also found the SILS technique easier to set up.

The cost of the two techniques is also important to consider. The GelPoint costs £306.90 and is a disposable single use system. In contrast, at our institution, we use metal reusable laparoscopic ports which are sterilised in house at a cost of £38.01 per episode. However, this set requires a considerable initial cost for purchase and then ongoing maintenance charges. Furthermore, the 3-point technique also requires the use of an endocatch bag costing £59.91 per case.

Discussion

Gonadal tissue cryopreservation is a successful modality to provide hope of future fertility for children undergoing gonadotoxic therapies for a number of malignant and non-malignant conditions. The provision of this service is increasing, as are the number of children being referred for ovarian tissue retrieval. Laparoscopic oophorectomy is a safe and effective method of retrieval for ovarian tissue cryopreservation. Conventional 3-port laparoscopy has classically been the approach of choice; however, the authors' experience suggested a SILS approach may be superior for reasons that include shorter operative time and better cosmesis. Karayani et al. also published that the ease of specimen delivery using this technique has been shown to lead to better preservation of ovarian tissue and result in a better-quality specimen for cryopreservation [5].

Data analysis has shown mean operative time was shorter in the SILS group, this difference was statistically significant. The quickest SILS case was only 15 min skin to skin, and the authors believe that the difference between the two techniques may be greater than demonstrated when one factors in the learning curve for SILS. We feel that a single incision, ease of specimen delivery and the ease of setup maybe contributory factors to the faster operating time. This difference was significant despite the reduction in the number of patients,

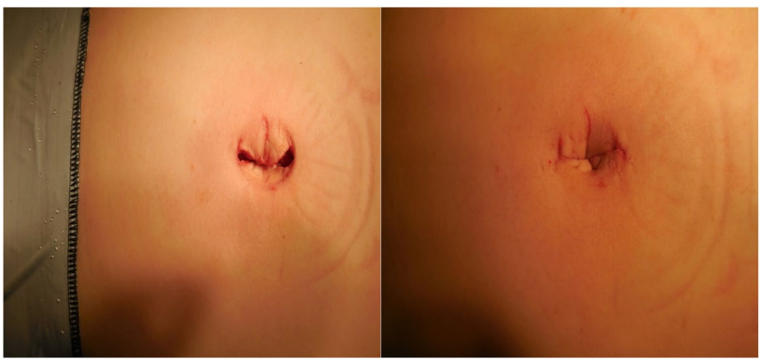

Fig. 5 Transumbilical incision (left) and after closure (right)

as many patients had additional procedures and were therefore excluded from the operative time analysis. A recent publication in the Journal of Paediatric Surgery also commented that in 76% of patients the ovarian cryopreservation was performed in conjunction with an ancillary procedure [6]. Fertility preservation is a choice for children undergoing cancer treatment and, if possible, must be performed at the same time as other necessary treatments in order to prevent multiple episodes of general anaesthesia. At our institution, we have dedicated cryopreservation theatre lists which allow time for ancillary procedures to be performed by the relevant clinical teams.

We believe that SILS is yet another resource in the ever-expanding armamentarium for surgeons and does require specific training as a result of the instrument crossover. Logistically, it simply requires the specific port which can be used with nearly all existing laparoscopic equipment. In the context of transferable surgical skills, we are also currently using this technique for other indications in which clean intra-abdominal conditions and the assistance of laparoscopy is beneficial. This may include Meckel's diverticulum or excision of duplication cysts where the lesion(s) is identified and delivered with ease through the SILS incision. Additionally, patients favoured the cosmetic appearance of the single-incision approach when asked during their return to hospital for oncology treatment. Although safe surgery is of the upmost importance, with advancing surgical techniques, improving cosmetic results may be safely considered.

Our data analysis has shown that SILS is not inferior to conventional 3-port laparoscopy in many domains. No difference was found between the rates of complications, length of hospital stays or post-operative analgesia requirement. Analgesia requirements were not standardised and therefore direct comparison and determination of a statistically significant difference was not possible. However, it is of note that those who underwent a single-incision approach did not require more post-operative pain relief. Interestingly, 54% of conventionally treated compared to 45% SILS patients were managed with patient or nurse controlled analgesic systems post-operatively (PCA/NCA).

Decision to commence PCA or NCA systems is made predominantly by the senior anaesthetist. It is possible this difference may have been due to lower levels of post-operative pain in the SILS group or perceived lower levels of pain from the anaesthetic team in patients with one incision compared to those with multiple incisions. Whilst many patients had concurrent procedures, the majority of these were line insertions. The standard local protocol for analgesia for a line insertion would be local anaesthetic plus oral analgesia as required. A standardised pain relief protocol and further prospective investigation into analgesic requirements will be required to analyse this further.

A detailed comparison of length of stay was not possible as this was confounded by other factors including position on the operating list, distance from home and the performance of concurrent procedures. This service is national and so many patients travel a considerable distance to undergo this procedure and remain in hospital overnight for non-clinical reasons. Furthermore, given comorbidities and the need for timely commencement of treatment, their care is immediately transferred to the oncology term for initiation of inpatient medications. One patient who underwent insertion of a gastrostomy had a planned inpatient stay of 3 days to manage the feeding tube.

This retrospective review is limited by the size of the population studied. Although the number of cases performed is increasing rapidly, the total number of patients for whom this procedure has been performed remains small. This limitation is impaired further due to the nature of the service offered, performing concurrent procedures where possible means detailed analysis of operative and set up times and analgesic requirements would require a prospective study to more accurately determine a statistically significant difference in these parameters.

Conclusions

SILS is an acceptable technique in ovarian cryopreservation allowing a quicker operative time, easier delivery of the ovary and better cosmesis. A learning curve is recognised due to the ergonomics of single port laparoscopy; however, the technique can be established easily in departments with existing laparoscopic capabilities. This is the first paper which establishes this within a paediatric surgical setting.

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Authors' contributions
Metcalfe, Kiloran; data collection, data analysis, write up. Ghattaura, Harmit; data analysis, write up, submission, corresponding author. Elbourne, Ceri; data collection, data analysis, write up. Ashour, Khaled; inception of idea, supervision in all stages. Lane, Sheila; inception of idea, supervision in all stages. Lakhoo, Kokila; inception of idea, supervision in all stages, senior author. The author(s) read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

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Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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References

1. Biasin E, Salvagno F, Berger M, Nesi F, Quarello P, Vassallo E. Ovarian tissue cryopreservation in girls undergoing haematopoitic stem cell transplant: experience of a single centre. Bone Marrow Transplant. 2015;50:1206–11.
2. Pacheco F, Oktay K. Current succes and efficiency of autologous ovarian transplantation: a meta-analysis. Reprod Sci. 2017;24:1111–20.
3. Falcetta FS, Lawrie TA, Medeiros LR, da Rosa MI, Edelweiss MI, Stein AT, et al. Laparoscopy versus laparotmy for FIGO stage I ovarian cancer. Cochrane Database Syst Rev. 2016;10(10):CD005344.
4. Behnia-Willison F. Single incision laparoscopic surgery (SILS) in gynaecology: feasibility and operative outcomes. Aust N Z J Obstet Gynaecol. 2012;52:366–70.
5. Karavani G, Schachter-Safrai N, Chill HH, Mordechai Daniel T, Bauman D, Revel A. Single-incision laparoscopic surgery for ovarian tissue cryopreservation. J Minim Invasive Gynecol. 2018;25(3):474–9.
6. Rowell EE, Corkum KS, Lautz TB, Laronda MM, Walz AL, Madonna MB, Lochart BA, Reynolds M. Laparoscopic unilateral oophorectomy for ovarian tissue cryopreservation in children. J Pediatr Surg. 2019;54(3):543–9.

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