Laparoscopic tubal reanastomosis versus in vitro fertilization: cost-based decision analysis

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Article Outline

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Key words: cost-effectiveness, decision analysis, in vitro fertilization, multiple gestation, tubal reversal

Abstract

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Regret after tubal ligation continues to be a problem. After tubal ligation, couples have the option of tubal surgery or in vitro fertilization (IVF).

Study Design

Using decision analysis techniques, we compared cost-effectiveness of tubal reanastomosis by tubal type vs tubal surgery or in vitro fertilization (IVF) for 3 separate age groups of women: <35 years of age, 35 to 40 years of age and >40 years of age. Tubal techniques was divided into type A, those with more favorable prognosis because of the likelihood of having a more significant length tube at time of reanastomosis and type B, those with a worse prognosis of success. We incorporated delivery costs to address the impact of high order multiples in IVF. Data were extracted by studies available in the literature. All costs were adjusted to 2012 US dollars. One-way and 2-way sensitivity analyses were performed.

Results

The laparoscopic reanastomosis of type A dominated the other groups, because it was more effective and less costly then type B and IVF. However, when women were >40 years old with a history of type B, IVF was favored when its costs were at the lower limit.

Conclusion

The most cost-effective choice for a woman desiring pregnancy after tubal ligation is laparoscopic reanastomosis after a prior clip or ring tubal ligation for women ≤40 years old. It is also the most cost-effective for the oldest cohort, assuming IVF costs are greater than $4500.

Key words: cost-effectiveness, decision analysis, in vitro fertilization, multiple gestation, tubal reversal

Currently, 700,000 women have tubal ligation performed every year.¹ The use of long-acting contraception (LARC) has been a major focus within the US.² LARC has the distinct advantage of allowing a patient to have highly effective contraception that can be changed in the future. Counseling is essential; a long-acting reversible contraception option may be a better choice.
comparing bilateral tubal ligation in women who are not concrete in their decision and especially in younger women in whom the risk of regret is higher. Yet, irreversible contraception such as tubal ligation is still performed to a significant degree.

Although women are counseled that tubal ligation is a permanent form of contraception, 2-30% of women subsequently regret their decision. After tubal ligation, if a woman is interested in future childbearing she can proceed with surgical tubal reanastomosis or in vitro fertilization (IVF). The type of tubal ligation performed can influence the success rates of surgical reanastomosis. This is due to the likelihood of having a more substantial remnant tubal length for reanastomosis. For instance, the success rates of tubal reanastomosis as measured by subsequent live birth after a clip or ring placement is estimated at 56.6-100% compared with 40-74.3% success with history of Pomeroy, Parkland, electrocautery, and other modalities. Age is also known to be an important prognostic factor with women less than 40 years of age having higher success rates of live birth compared with older women. Thus, when deciding which modality to recommend, practitioners have to consider multiple factors. The recommendation for surgery vs IVF has traditionally been based on multiple factors including: age of the women, type of tubal ligation procedure, ovarian reserve, surgical candidacy, other infertility diagnosis, insurance coverage, number of children desired, and others.

Recently, an American Society of Reproductive Medicine (ASRM) Committee Opinion concluded that although IVF has a higher pregnancy rate, tubal anastomosis, with significantly higher cumulative pregnancy rates, is more cost-effective for all types of tubal ligation procedure, ovarian reserve, surgical candidacy, other infertility diagnosis, insurance coverage, number of children desired, and others.

The most cost-effective strategy for women with a history of tubal ligation interested in future childbearing remains somewhat uncertain. There are currently neither longitudinal comparative studies nor randomized trials addressing this, and either would be difficult to accomplish. We sought to compare cost-effectiveness between tubal reanastomosis and IVF incorporating the impact of age, type of tubal procedure, and delivery costs to address the impact of multiples with IVF.

Materials and Methods
This study compared the cost-effectiveness of laparoscopic tubal reanastomosis using 2 different types of tubal ligation compared with each other, as well as, IVF. The types of tubal ligation techniques were divided into type A—the more favorable prognosis group (ie, clip or ring tubal ligation) because of the likelihood of having a more significant length of tube remaining at the time of reanastomosis and type B—the less favorable prognosis group encompassing all other types of tubal ligation (ie, postpartum tubal ligation, electrocautery, Parkland, or unknown type). Both types of tubal ligation reanastomosis were compared with each other and to IVF. Laparoscopic tubal reanastomosis was chosen over open technique in attempts to minimize costs associated with the procedures. The likelihood of patients having a tubal ligation with type A vs B was estimated to be 46.1% and 53.90%, respectively.

Probability estimates for a successful reanastomosis and IVF were extracted from published data and were formulated into a decision tree comparing types of tubal ligation—type A or B—vs IVF (Table 1). The average pregnancy following surgery was 12-24 months, the range within the literature was 2-88 months. Society for Assisted Reproductive Technology (SART) rates were used to estimate live birth rates from assisted reproductive technologies (ART) based on age and risk of multiples was based. Only fresh IVF outcomes were considered. Each scenario that used ART was allowed to run a total of four rounds to simulate the number of times insurance would cover attempted pregnancy with IVF in states with state mandated-insurance. Although insurance companies may cover a different number of cycles depending on their policy and the respective state, we chose to allow our model to run four times to simulate a middle range number of cycles covered in states with mandated insurance. Three separate trees were created to compare patients of the following ages: less than 35 years of age, 35 to 40 years of age, and greater than 40 years of age. The decision tree model was constructed using TreeAge version 3.5 (Tree Age Software, Williamstown, MA).

### Table 1. Probability estimates

<table>
<thead>
<tr>
<th>Clinical situation</th>
<th>Age range</th>
<th>Base case (range)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful tubal reanastomosis with A</td>
<td>NA</td>
<td>75% (56.6–100%)</td>
<td>5, 6, 7</td>
</tr>
<tr>
<td>Successful tubal reanastomosis with B</td>
<td>NA</td>
<td>67.5% (40–74.3%)</td>
<td>5, 6, 7</td>
</tr>
<tr>
<td>Successful live birth with tubal reanastomosis A and B</td>
<td>NA</td>
<td>72.5% (18–85%)</td>
<td>5, 7, 11, 12, 13, 14, 15</td>
</tr>
<tr>
<td>Live birth rate (singleton) after tubal reanastomosis [assume same for tubal A and B]</td>
<td>≤35</td>
<td>79.89% (50–100%)</td>
<td>5, 17</td>
</tr>
<tr>
<td>Live birth rate (twins) after tubal reanastomosis [assume same for tubal A and B]</td>
<td>≤35</td>
<td>1.09% (0–2%)</td>
<td>5, 17</td>
</tr>
<tr>
<td>Live birth rate (triples or more) after tubal reanastomosis [assume same for tubal A and B]</td>
<td>≤35</td>
<td>0.014% (0–0.3%)</td>
<td>5, 17</td>
</tr>
<tr>
<td>IVF live birth rate singleton</td>
<td>≤35</td>
<td>27.3% (13–40%)</td>
<td>16, 18</td>
</tr>
<tr>
<td>IVF live birth rate twins</td>
<td>≤35</td>
<td>12.9% (6–24%)</td>
<td>16, 18</td>
</tr>
<tr>
<td>IVF live birth rate triplets or more</td>
<td>≤35</td>
<td>1.3% (0–3%)</td>
<td>16, 18</td>
</tr>
<tr>
<td>Live birth rate (singleton) after tubal reanastomosis [assume same for tubal A and B]</td>
<td>35–40</td>
<td>66.08% (50–100%)</td>
<td>5, 17</td>
</tr>
<tr>
<td>Live birth rate (twins) after tubal reanastomosis [assume same for tubal A and B]</td>
<td>35–40</td>
<td>0.9% (0–2%)</td>
<td>5, 17</td>
</tr>
</tbody>
</table>
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Costs for tubal reanastomosis and IVF were extrapolated from published data and were adjusted to 2012 US dollars using the medical care component of the Consumer Price Index. Studies that described costs were preferred and chosen when available. When only charges were available, they were converted to costs using 0.6 cost-to-charge ratios. Costs were also converted from foreign currency to US dollars with the average exchange rates for that given calendar year. The study also incorporated delivery costs of singleton; twin and multiple births to address the impact of high order multiples with ART. Only direct costs were considered.

Table 2. Cost estimates

<table>
<thead>
<tr>
<th>Service</th>
<th>Base case (range)</th>
<th>Charge or cost</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSC tubal reanastomosis</td>
<td>$8006.67 ($1097.87–8006.67)</td>
<td>Cost</td>
<td>13, 19, 20</td>
</tr>
<tr>
<td>Delivery cost singleton</td>
<td>$15,238.63</td>
<td>Charge</td>
<td>17</td>
</tr>
<tr>
<td>Delivery cost twins</td>
<td>$58,736.43</td>
<td>Charge</td>
<td>17</td>
</tr>
<tr>
<td>Delivery cost triplets</td>
<td>$169,900.22</td>
<td>Charge</td>
<td>17</td>
</tr>
<tr>
<td>IVF cycle</td>
<td>$10,043.32 ($7,363.67–16,015.99/cycle)</td>
<td>Charge and cost</td>
<td>13, 20, 21, 22, 23, 24</td>
</tr>
</tbody>
</table>

All cost expressed in 2012 US dollars; older references were adjusted to 2012 US dollars using the Consumer Price Index.

The effectiveness measure in the analysis was live birth, and the primary cost-effective outcome was the marginal cost (USD) per live birth for each strategy. The primary outcome of the decision analysis is cost per live birth. Ectopic pregnancies are increased in patients with a history of tubal reversal and in patients that have undergone ART. Ectopic pregnancy is estimated at 2% in the general population and in one study comparing ectopic pregnancy in tubal reanastomosis vs in ART was 6.7% vs 5.6%, respectively. Thus, ectopic gestation is at increased risk for patients in both groups.

The most effective and least costly is noted as the dominant strategy in the model. Difference in cost and effectiveness were used to calculate the marginal costs and marginal effectiveness respectively for each model. One-way sensitivity analysis was used to test the model's probability changes and costs, with base cases and ranges derived from published data. When ranges were not available from literature, the range was set at ± 50% of the base case value. Two-way sensitivity analyses were also conducted.

The study was considered exempt by the institutional review board at University of Illinois Medical Center At Chicago.

Results

Decision trees were formulated for each age group using cost-based estimates. Base-case estimated costs were cheapest for Type A reanastomosis per live birth at every age. It was estimated at $19,300/live birth a for 35 years old, $23,000/live birth at 35-40 years old, and $26,200/live birth for woman greater than 40 years of age. Marginal costs for type B reanastomosis and IVF ranged from $1000–8000. Type A reanastomosis was also more effective per live birth for each age group compared with the other 2 strategies, and thus the dominating or preferred strategy. This was true for all 3 ages using base-case estimates
Figure.
Two-way sensitivity analysis for the oldest cohort

Two-way sensitivity analysis is depicted for women greater than 40 years of age. The analysis of IVF cost and successful singleton live births are compared and the dominant strategy is depicted. Type A tubal reanastomosis dominates for the majority of cases, except when IVF costs become low and/or success of type A is less than 50% in which case type B dominates.

IVF, in vitro fertilization.


The marginal cost effectiveness (ie, each additional live birth performed with type B tubal reanastomosis and IVF compared with type A tubal reanastomosis) was $58,300 and $30,900, respectively, for the youngest age cohort. In the 35 to 40-year cohort, the marginal cost effectiveness was $111,000 and $44,000 respectively for type B reanastomosis and IVF. Lastly, the marginal cost-effectiveness for the oldest age cohort was $38,400 and $9,540 for type B reanastomosis and IVF, respectively (Table 3).

Laparoscopic reanastomosis of a prior clip or ring tubal ligation (type A) dominated the other less favorable (type B) and IVF at every age. In other words, it was more effective and less costly than type B reanastomosis or IVF. Type B reanastomosis also dominated IVF in that it was more effective and less costly.

The marginal cost effectiveness estimates when comparing the 2 tubal types are higher values because efficacy is almost equivalent between the 2 tubal types. Because marginal cost-effectiveness is calculated by marginal cost divided by marginal effectiveness, the small denominator results in a large estimated cost difference.

One-way sensitivity analysis was performed to demonstrate the robustness of the model. When women were older than 40 and had a history of tubal type B, if the cost of IVF was in the lower limit of the range reported in the literature ($4500 US), then IVF was favored. IVF costs had to be less than reported in the literature (<$3000) for it to be favored over either tubal strategy for the 2 younger cohorts. In addition, when type A strategy was assessed at its lowest pregnancy rate within the range reported in the literature, and type B was at its highest efficacy rate, then type B was the favored strategy. Of note, both procedures were favored over IVF. In particular for woman less than 35 years of age, type A strategy was favored over type B when subsequent successful pregnancy rates were greater than 80%. Conversely, type B strategy was favored when it had a subsequent pregnancy rate that was greater than 88%. For patients between the ages of 35-37 years of age, if type A tubal reanastomosis had a successful pregnancy rate of less than 70% then type B was favored when it was greater than 70% successful. Lastly, for the oldest cohort, the cut point at which the strategy type A was no longer favored over type B was at approximately 50% subsequent successful pregnancy rate.

Two-way sensitivity analysis was done comparing the 2 types of tubal ligation processes and confirmed the above noted cut-points for each age cohort analyzed (Figure).
more cost-effective than IVF at all age groups. When analysis was conducted using tubal reversal, subsequent pregnancy rates at the extremes in the literature, the preferred strategy between the "favorable" and "nonfavorable" type ligation techniques varied. In particular, the older a patient was, the lower the cut point in pregnancy rates occurred; more specifically, for women >40 years of age, tubal reversal success of type A had to be less than 50% for type B to be favored, compared with 80% in the youngest cohort. This information can be helpful in individualizing recommendations to particular patients. Either way, both tubal reversal strategies were favored over IVF. It was only for the oldest cohort that IVF was favored over the woman undergoing tubal reversal with a less favorable ligation type. This occurred when IVF costs were at the lowest level reported in the literature, namely $4500 2012 US dollars.

Few decision-analysis of this type have been conducted. Our analysis differed to others conducted, in that it included 3 age groups, differentiated by type of tubal ligation performed and included delivery costs. We believe the incorporation of these variables will assist clinicians in applying the results to individual patients.

The inclusion of delivery costs, in particular costs associated with twin and high-order multiples, more clearly define the true costs of ART procedures given that IVF is known to significantly increase the incidence of multiples. Societal cost effectiveness and policy regarding potential insurance coverage of tubal reversal and/or IVF in a woman that has undergone voluntary sterilization need to consider the significant costs related to multiples.

Limitations of this study should be acknowledged. This study is limited to an examination of the direct medical costs incurred and did not include indirect costs such as lost wages during any of the treatments or childcare. We elected to focus on the direct medical costs because the decision to proceed with a particular algorithm is often dependent on the demands of medical insurance that consider direct costs only. It should be noted the success rates of laparoscopic tubal reanastomosis were taken from those published in the literature and are likely biased by surgeons who are very skilled in the procedure, but that leads to the importance of continued education and practice in this procedure in teaching centers and by practitioners to give patients the best options. In addition, all treatments used are considered minimally invasive procedures with limited recovery time. In particular, we limited our analysis to tubal reversal performed using conventional laparoscopy. Robotic assisted laparoscopic tubal reanastomosis was not incorporated into this cost-effective analysis because of the limited published data for success rates and cost. A recent study showed median difference in costs of the procedures was $1446 between a mini laparotomy vs robotic assisted laparoscopic tubal reanastomosis, however, limited data exists between laparoscopy alone and robotic assisted. Although, under base case assumptions, the tubal reversal strategies appear to be preferred, some may challenge that notion because the cost that is reasonable for society to bear to produce a live-born remains controversial. Yet, many ART-based decision models have used live birth as the clinical outcome. Standard effectiveness outcomes such as QALYs (quality adjusted life years) were not used, because their use in certain pregnancy situations can be difficult to interpret and sometimes misleading. Furthermore, neonatal outcomes and associated costs were not included in the analysis.

The clinical decision between tubal reversal and IVF for patients with history of voluntary sterilization is impacted by many things including: patient age, body mass index, desired number of subsequent children, ovarian reserve markers, partner semen analysis, and arguably physician preference.

Ultimately, the true test of superiority of one treatment strategy over another requires a randomized control trial. Conducting a randomized control trial in this situation is unlikely given the cost and feasibility of performing such a study; thus, there is a role for decision analysis in addressing this clinical situation. Although our analysis strongly favors tubal reversal, particularly for those women with a history of clip or ring ligation, this is dependent on highly skilled surgeons to perform these surgeries. Studies cited in this study were from groups with extensive surgical experience. As reproductive endocrinology and infertility training becomes arguably, less focused on surgery, the question exists about who should be performing the reversal. Our results support the continued training of gynecologists in minimally invasive approaches to tubal reversal.

References


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