The Value of Serum Follicle-Stimulating Hormone in Predicting Successful Surgical Sperm Retrieval in Cases of Male Infertility: A Literature Review

Editor's Pick

My pick for this issue is the article entitled: 'The Value of Serum Follicle-Stimulating Hormone in Predicting Successful Surgical Retrieval in Cases of Male Infertility: A Literature Review', which faces the important problem of predicting the attainment of spermatozoa after testis biopsy in patients with azoospermia. Several papers in the literature analysed the predicting ability of serum follicle-stimulating hormone (FSH) levels in sperm retrieval for testicular sperm extraction. Here, the authors reviewed 35 articles with the aim of identifying a possible threshold FSH value. In general, successful sperm retrieval is associated with lower FSH levels (>8.5). Whether successful sperm retrieval is associated with live birth is, however, not clear from these studies. Clearly, as suggested, more studies will be necessary, particularly those considering other testicular serum markers as additional predictors.

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Abstract

Azoospermia is a common cause of male infertility; however, surgical sperm retrieval (SSR) and subsequent intracytoplasmic sperm injection offers couples the chance to have a biological child. SSR success is highly variable and dependent on a number of factors. One such factor is male follicle-stimulating hormone (FSH), which has been researched extensively. The aim of this literature review is to ascertain if there is a 'cut off' FSH value that correlates with successful SSR, whether this value differs depending on method of SSR, and if there is a correlation between male FSH level and obstetric outcomes. Thirty-five articles were identified and reviewed, with 10 papers suggesting FSH cut off values. These ranged from <8.5 to <25.0 IU/L, with a

mean value of 14.0 IU/L. Generally the results suggested that lower FSH values were associated with increased SSR success. Few papers considered pregnancy and birth outcomes following intracytoplasmic sperm injection with surgically retrieved sperm, and there was no clear correlation with male FSH levels. Clinical implications include considering FSH results when counselling patients about both SSR and intracytoplasmic sperm injection. Suggested future research implications are to further investigate the predictive role of FSH in combination with other clinical and endocrinological markers.

Key Points

1. Surgical sperm retrieval is one method to provide males with azoospermia the chance to father a biological child but success depends on numerous variables, including follicle-stimulating hormone.
2. Lower follicle-stimulating hormone values were associated with increased surgical sperm retrieval success, especially in obstructive azoospermia.
3. Infertility is associated with feelings of disappointment and a loss of control worldwide, and clinicians have an ethical obligation to provide evidence-based management and individualised care.

INTRODUCTION

Male factor aetiologies account for approximately 50% of infertility in couples,[1] with azoospermia diagnosed in up to 15% of infertile males.[2] The World Health Organization (WHO) semen analysis parameters are universally used and define azoospermia as an absence of spermatozoa identified in wet or centrifuged ejaculate samples.[3] Azoospermia is classified into either obstructive (OA) or non-obstructive causes (NOA), with impaired spermatogenesis. Treatment for both consist of surgical sperm retrieval (SSR) with a variety of techniques. These include testicular sperm extraction with microscopy with (mTESE) or without (TESE), testicular sperm aspiration, microsurgical epididymal sperm aspiration, percutaneous epididymal sperm aspiration (PESA), and fine needle aspiration (FNA). Surgically retrieved spermatozoa are then utilised in intracytoplasmic sperm injection (ICSI). This allows males with azoospermia to father genetically-related children, and remove the necessity for sperm donors or adoption.

Despite several methods, SSR outcomes can be of variable success, particularly in cases of NOA.[4] Spermatogenesis is controlled by a complex neuroendocrine axis including follicle-stimulating hormone (FSH). Although the relationship between FSH and SSR has been explored previously, the results have not always been consistent. Therefore, the current evidence was assessed through a literature review to ascertain if FSH levels can correlate with SSR outcomes, in order to update clinicians and help patients make a more informed choice.

METHOD

Objectives

To evaluate if pre-operative serum FSH levels are predictive of subsequent successful SSR (TESE, mTESE, testicular sperm aspiration, microsurgical epididymal sperm aspiration, PESA, FNA) in cases of azoospermia prior to ICSI.

Outcomes

The primary outcome is to ascertain if FSH is predictive of successful SSR, and to determine a 'cut off' value. Secondary outcomes include whether different SSR methods have different cut off values, and if there is a correlation between FSH and clinical pregnancy or live birth outcomes following ICSI.

A literature review was conducted by performing a Medline search via Ovid from January 2002–2021. The search terms 'FSH', 'follicle-stimulating hormone', 'surgical sperm retrieval', 'testicular sperm extraction', 'microdissection testicular sperm extraction', 'testicular sperm aspiration',

Figure 1: Flowchart summarising the screening process of article selection.

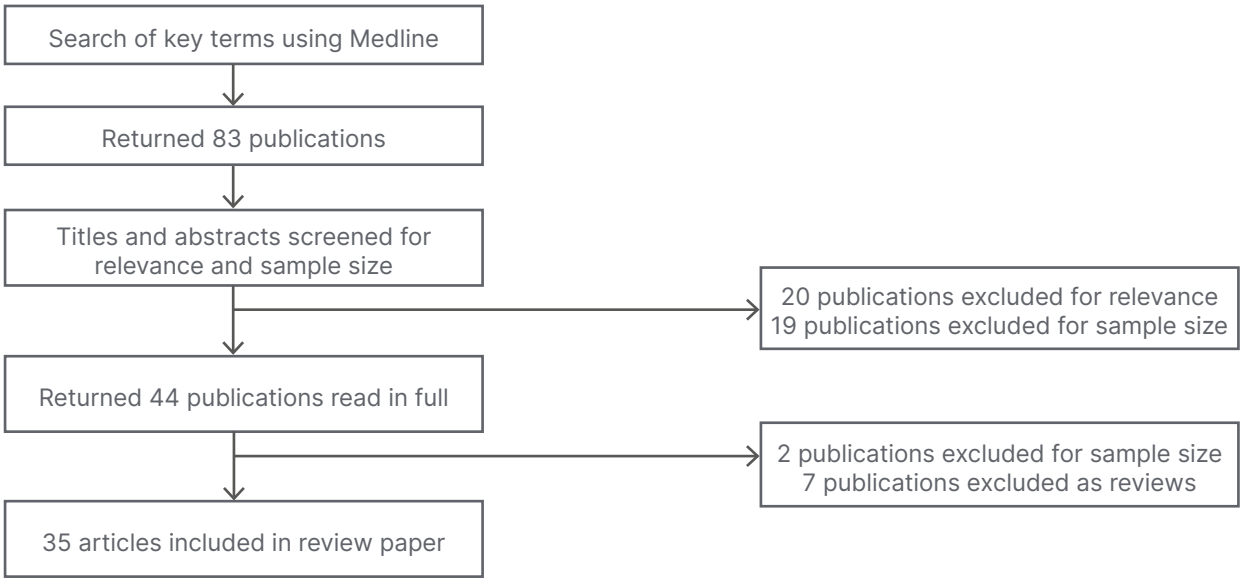

Table 1: Study characteristics and association between follicle-stimulating hormone and surgical sperm retrieval.

	Study Design	Sample size	Azoospermia classification	SSR technique	Results	Suggested FSH 'cut off' value	Comments
Amjad et al.[5]	Prospective cohort study; single centre	100	Mixed	TESE/mTESE	Mean FSH significantly higher in unsuccessful group (14.12±2.30 versus 23.87±2.34; p=0.004; AUC: 0.675 (p<0.05)	12.16 µIU/mL; sensitivity: 67.0%; specificity: 62.0%	Pregnancy outcomes not considered
Majzoub et al.[6]	Retrospective analysis; single centre	297	NOA	TESA±mTESE	Median FSH successful versus unsuccessful SSR 5 (2.0-9.5) IU/L versus 12 (5.0-20.0) IU/L; (p=0.000); AUC: 0.742	<8.5 IU/L (95% CI: 0.13–0.04)	Pregnancy outcomes not considered
Cayan et al.[7]	Retrospective observational analysis; multicentre	327	Mixed	mTESE	Group with FSH <17.25 µIU/mL significantly more likely to have successful SSR (72.3% versus 44.4%; p=0.000)	N/A	Pregnancy outcomes considered, but not in regard to FSH; all had history of cryptorchidism
Liu et al.[8]	Retrospective analysis; multicentre	294	NOA	TESA/mTESE	Successful TESA FSH (12.20±5.72 versus 19.60±8.68; p=0.003);	N/A	Pregnancy outcomes not considered

Table 1 (continued):

					successful mTESE FSH (31.62±13.76 versus 25.51±12.06; p=0.001); FSH cut off for TESE <19 µIU/mL and >19 µIU/mL for mTESE (ROC analysis)		Excluded patients with ejaculatory disorders or hypogonadotropic hypogonadism; defined success as retrieval of one sperm
Zeadna et al.[9]	Retrospective cohort study; single centre	119	NOA	TESE	No statistical difference in FSH between successful and unsuccessful groups; FSH variable in gradient-boosting trees predictive model (AUC: 0.807; FSH cut-off 18.95 IU/L; variable importance: 0.014)	N/A	Pregnancy outcomes not considered; excluded patients with gonadotoxin usage and hypogonadotropic hypogonadism
Zhang et al.[10]	Retrospective observational analysis; single centre	155	NOA	mTESE	FSH >24.8 IU/L significantly higher SSR success than where FSH >12.4 IU/L (p=0.033)	N/A	Pregnancy outcomes not considered; only idiopathic NOA included
Jahromi et al.[11]	Prospective cross-sectional study; single centre	171	NOA	mTESE	N/A	14.6 µIU/mL; AUC: 0.88 (95% CI); sensitivity: 83.5% (73.5–90.9%); specificity: 80.3% (69.5–88.5%)	Pregnancy outcomes not considered; excluded patients with hypogonadotropic hypogonadism
Nariyoshi et al.[12]	Retrospective clinical audit; two centres	806	NOA	mTESE	FSH <14 IU/L; AUC 0.61	N/A	Pregnancy outcomes not considered
Barbotin et al.[13]	Retrospective analysis; single centre	225	NOA	TESE	FSH statistically lower in successful group (median: 19.2 IU/L versus 23.6 IU/L; p=0.007)	N/A	Pregnancy outcomes considered, but not with respect to FSH; exclusively patients with cryptorchidism; excluded concurrent aetiologies for azoospermia
Busch et al.[14]	Retrospective analysis; single centre	1,075	Mixed	mTESE	FSH significant in success in unexplained azoospermia (p=0.006)	N/A	Pregnancy outcomes not considered; extensive exclusion criteria
Ma et al.[15]	Retrospective cohort analysis; multicentre	597	NOA	FNA	Increased FSH significantly associated with failed SSR (p<0.001)	N/A	Pregnancy outcomes not considered

Table 1 (continued):

Blok et al.[16]	Retrospective analysis; single centre	231	OA	OESA	Univariate analysis FSH: associated with SSR success rates (p=0.01); multivariate logistic regression: FSH negatively associated with SSR success (p=0.021; OR: 0.87; 95% CI: 0.78–0.98)	N/A	Pregnancy outcomes considered, but not with respect to FSH
Zhu et al.[17]	Prospective analysis; single centre	403	NOA	TESE/ mTESE	FSH successful SSR: AUC 0.87 (95% CI: 0.83–0.90). If FSH >12.4 IU/L: ROC AUC: 0.55 (95% CI: 0.48–0.63); suggested cut-off ≤15.45 IU/L (sensitivity: 36.67%; specificity: 78.17%)	≤9.00 IU/L; sensitivity: 80.75%; specificity: 90.00%	Pregnancy outcomes not considered; success defined as retrieval of spermatozoa or spermatids; no reference range for elevated FSH in analysis
Amer et al.[18]	Retrospective cross-sectional analysis; single centre	1,395	NOA	mTESE	No significant difference in mean FSH in successful and unsuccessful groups: (19.52±13.08 µIU/mL versus 19.81±14.21 µIU/mL; p=0.767); ajority in successful group had 'high FSH': >8 IU/L (p=0.02); logistic regression analysis: 'high FSH' significantly associated with success (OR: 1.6; 95% CI: 1.2–2.1; p=0.003)	N/A	Pregnancy outcomes not considered; extensive exclusion criteria
Maglia et al.[19]	Cross-sectional study; single centre	145	NOA	TESE/ mTESE	mTESE significantly more successful than TESE if FSH >18 µIU/ml (60.0% versus 12.9%; p=0.001) Overall cohort analysis: FSH independent predictor of SSR failure (OR: 1.11; p=0.008)	N/A	Pregnancy outcomes not considered; males in interracial couples excluded
Gnessi et al.[20]	Retrospective analysis; single centre	486	Mainly NOA	TESE	Successful SSR correlated with lower FSH (15.70±12.22 versus 22.51±12.11; p< 0.01; OR: 0.96 /µIU); FSH included in SSR prediction score: AUC 95% CI: 0.843	N/A	Pregnancy outcomes not considered; all had previously failed SSR; 56/486 males had severe oligospermia or necrozoospermia
Caroppo et al.[21]	Retrospective analysis; single centre	356	NOA	TESE	Mean FSH significantly lower in successful TESE group (16.1, [95% CI: 1.79] versus 22.4 [95% CI: 2.32]; p<0.0001)	N/A	Pregnancy outcomes not considered; success defined as number of viable sperm equalled number of collected oocytes

Table 1 (continued):

Salehi et al.[22]	Retrospective cohort study; multicentre	170	NOA	TESE	Higher FSH correlated with lower chance of sperm retrieval (p<0.01)	N/A	Pregnancy outcomes not considered; success defined as ≥1 spermatozoa (regardless of motility)
Cissen et al.[23]	Retrospective cohort study; nationwide multicentre	1,371	NOA	TESE	FSH significantly lower in successful group (OR: 0.98; p=0.003; AUC: 0.64)	N/A	Pregnancy outcomes not considered
Guler et al.[24]	Retrospective analysis; single centre	271	NOA	TESE	Decreased FSH levels (11.0 9.5 IU-1 versus 22.3±16.0 IU-1) correlated to successful SSR (p=0.000)	N/A	Pregnancy and live birth rated considered, with no significant difference (p=0.817 and p=0.228, respectively); FSH best predictor of a successful TESE
Cetinkaya et al.[25]	Retrospective analysis; single centre	191	NOA	mTESE	FSH significantly higher in failed SSR group (24.9±15.2 versus 17.5±14.1; p=0.001) Idiopathic NOA showed FSH as an independent predictive factor for SSR outcome	15 µIU/ml; sensitivity: 75%; specificity: 51.2%; p=0.001; AUC: 0.656	Pregnancy outcomes not considered
Ramasamy et al.[26]	Retrospective review; single centre	1,026	NOA	mTESE	FSH not significant (p=0.66)	N/A	Pregnancy outcomes not considered
Abdel Raheem et al.[27]	Retrospective analysis; single centre	388	Mixed	TESE/ mTESE	NOA: increased FSH strongly negatively correlated to SSR rate (r=-0.208; p=0.001)	N/A	Pregnancy outcomes not considered; 112 patients had OA, all with normal FSH levels; 276 patients had NOA; 56% had raised FSH; success reported per testes
Enatsu et al.[28]	Retrospective analysis; single centre	329	NOA	mTESE	No FSH difference (p=0.42)	N/A	Pregnancy outcomes not considered; excluded males with normal FSH, testicular volume, or hypogonadotropic hypogodanism
Huang et al.[29]	Prospective analysis; single centre	305	NOA	TESE	FSH significantly lower in successful SSR (p<0.001)	11.05 µIU/mL; sensitivity: 83.5%; specificity: 74.5%	Pregnancy outcomes not considered; excluded patients with testosterone or gonadotrophin therapy

Table 1 (continued):

Nowroozi et al.[30]	Controlled cross-sectional study; single centre	385	NOA	TESA/ TESE	Mean FSH significantly lower in successful TESA group 13.0±4.7 IU/L versus 23.2±6.1 IU/L (p<0.001) FSH <15 IU/L was predictive of successful SSR with TESA (OR: 4.8; p=0.001)	N/A	Pregnancy outcomes not considered
Boitrelle et al.[31]	Retropective case series; single centre	280	NOA	TESE	FSH statistically lower in successful group (p=0.003; AUC: 0.656)	<20.5 IU/L; sensitivity: 68.5; specificity: 55.7; PPV: 63.8; NPV: 60.8	Pregnancy and live birth rates considered; excluded males with hypogonadotropic hypogonadism
Ramasamy et al.[32]	Retrospective analysis; single centre	126	NOA	Repeat mTESE	FSH significantly lower in successful group (23.1±12.4 versus 29.2±12.8; p=0.04)	N/A	Pregnancy outcomes considered, but not in respect to FSH
Ma et al.[33]	Retrospective analysis; single centre	280	NOA	TESE	FSH significanly lower in successful group in training set (13.7 ± 6.8 IU/L versus 16.2 ± 5.8 IU/L; p=0.02). Difference not significant in testing set (p=0.09)	14.32 µIU/L; sensitivity: 70.7%; specificity: 68.2%	Pregnancy outcomes not considered
Tuttleman et al.[34]	Retrospective analysis; single centre	283	Mixed	TESE	Lower FSH associated with higher chance of success. ROC analysis (AUC: 0.71; p<0.0001)	10 U/l (95th percentile; n=179)	Pregnancy outcomes not considered; excluded males with oncological aetiologies
Zitzmann et al.[35]	Retrospective cohort study; single centre	203	Mixed	TESE	FSH significantly lower in: successful SSR 4.8 IU/L (1.4–40.0) versus 17 IU/L (1.2–47.8; p<0.001); achieving clinical pregnancies 4.5 IU/L (range: 1.4–19.3) versus 6.6 IU/L (range: 1.2–47.8; p=0.009); live births 4.4 IU/L (range: 2.1–19.3) versus 10.9 IU/L (range: 1.2–47.8; p=0.014). FSH >20 IU/L; ROC: 100% specificity for prediction of no pregnancy (p=0.008) or no live birth (p=0.013)	N/A	Pregnancy and live birth rates considered; success defined as elongated spermatids extracted; male cigarette smokers included
Samli et al.[36]	Retrospective analysis; single centre	303	NOA	TESE	No significant difference in FSH SSR rates (p=0.35)	N/A	Pregnancy outcomes not considered

Table 1 (continued):

Raman et al.[37]	Retrospective analysis; single centre	275 males; 321 TESE	NOA	TESE	No significant difference in FSH SSR rates in patients with cryptorchidism (p=0.22) or without (p=0.53)	N/A	Pregnancy outcomes considered but not in respect to FSH 38/275 had cryptorchidism
Friedler et al.[38]	Retrospective analysis; single centre	175	Mixed	PESA/ TESE	No significant correlation with FSH and successful SSR, implantation rate, pregnancy or miscarriage	N/A	Pregnancy outcomes considered
Vernaeve et al.[39]	Prospective analysis; single centre	185	NOA	TESE	N/A	<25 IU/L; sensitivity: 74.3%; specificity: 44.3%; AUC: 0.56	Pregnancy outcomes not considered; patients with hypogonadotropic hypogonadism excluded

AUC: area under receiver operating characteristic curve; CI: confidence interval; FSH: follicle-stimulating hormone; FNA: fine needle aspiration; mTESE: testicular sperm extraction with microscopy; N/A: not applicable; NOA: azoospermia with a non-obstructive cause; NPV: negative predictive value; OA: azoospermia with an obstructive cause; OESA: open epididymal spermatozoa aspiration; OR: odds ratio; PESA: percutaneous epididymal sperm aspiration; PPV: positive predictive value; ROC: receiver operating characteristic curve; SSR: surgical sperm retrieval; TESE: testicular sperm extraction without microscopy.

'percutaneous epididymal sperm aspiration', 'azoospermia*', and 'predict*' were used. Eighty-three articles were identified and screened by the title and abstracts. Inclusion criteria applied to the studies were English language papers, randomised controlled trials (RCT), cohort studies, case-control studies, retrospective and prospective studies, and human-only studies. Exclusion criteria included papers with sample sizes of n=<100, letters to the editor, rapid response articles, case reports, review articles, and abstract proceedings. Two of the authors screened the results and reviewed the 35 full text papers included in the final analysis. Figure 1 depicts the screening processing.

RESULTS

Thirty-five articles met the inclusion criteria and were analysed. Table 1 outlines the study design, SSR technique, results, and authors' comments about the selected articles.

Twenty-seven studies considered NOA only; one study considered OA only; and seven studies included mixed aetiologies for azoospermia. Ten out of the 35 studies gave cut off FSH values predicting SSR success. These ranged from <8.5 to <25.0 IU/L, with a mean value of 14.0 IU/L. The results suggest lower FSH levels are associated with increased SSR success, although five papers did not demonstrate any significant relationship between FSH levels and SSR outcomes. Nine publications described pregnancy or birth related outcomes in addition to SSR results.[7,13,16,24,31,32,35,37,38] Five of these papers described ICSI outcomes following SSR procedures and consideration to FSH levels.

DISCUSSION

Indications for Surgical Sperm Retrieval

NOA is more common than OA, which is reflected in the respective proportion of articles covering each diagnosis. Additionally, some cases of OA can be treated with surgical correction to restore normal anatomy and avoid the necessity for SSR. However, males may show a continuum of disorder, with features of both NOA and OA.[7,35] Therefore, classification of

azoospermia may be of debatable value when counselling couples regarding treatment options, and an individualised approach to each case is preferred.

NOA testicular histopathological classifications include normal spermatogenesis, hypospermatogenesis, maturation arrest, and Sertoli cell-only syndrome. Genetic anomalies such as Klinefelter syndrome and Y chromosome microdeletions were in the exclusion criteria of 10 of the papers,[5,15,17-19,21,29,30,34,39] despite being well-established causes of azoospermia. Huang et al.[29] did identify FSH was not predictive for males with Klinefelter syndrome. Papers had variable exclusion criteria to decrease the risk of confounders; however, this made comparison by the authors more challenging.

Surgical Sperm Retrieval Techniques

Some publications compared mTESE with traditional techniques. Majzoub et al.[6] found that although FSH levels <8.5m IU/mL gave similar success rates between the two techniques, when all FSH ranges were considered, mTESE was more successful.

The authors' results have previously stated that SSR is less successful when males have higher pre-operative FSH levels, yet these articles suggest that males with higher FSH levels may benefit from microdissection techniques.[8,19,34] However, the number of publications comparing the two methodologies were very limited. Microdissection SSR requires advanced surgical training and is a longer procedure, therefore conferring marked resource implications and may reduce cost effectiveness.

FNA and PESA are simple, low cost, well-tolerated procedures, but as they are performed blind, they can yield less sperm compared to other SSR methods. Males may then have to undergo an additional TESE. Only one article about FNA[15] and one article including PESA[38] was identified, which is insufficient to conclude what FSH values would confer benefit from these procedures.

Strength of Evidence

The main limitations of these results are the heterogenous design of studies, and quality of evidence yielded. No RCTs were identified; however, it may not be feasible to apply RCT methodology to this topic, especially in blinding for surgical procedures.

Only five of the studies were prospective.[5,11,17,29,39] All of these papers are single-centre studies only; however, each identifies a FSH cut off for successful SSR, albeit these are still varied: <9 to <25 IU/L. Future prospective studies may help to refine the cut off range. For the remaining papers, it is well established that retrospective studies can carry bias when collecting data, or that crucial data may be missing that can affect reporting.

Many of the studies utilised regression analysis to form a predictive tool to calculate SSR success. Some of these studies included FSH in their algorithms, as they found it to be a significantly predictive factor.[23,25]

Alternative Variables for Surgical Sperm Retrieval Success

Frequently described clinical markers in the analysed papers included age and BMI. Testicular volume was considered most commonly,[6,8,10,15,31-34] but with varying ranges, again making a subgroup analysis difficult. Biomarkers include testosterone,[21] fructose,[34] α-glucosidase[34] and inhibin B,[29,39] which was described most frequently, and with good diagnostic accuracy.[17,31] The scope of this review intentionally did not consider the role of other variables as FSH is a cheap, established, readily available test. The authors therefore chose to focus on the potential diagnostic benefits of this sole marker.

Limitations

All SSR methods were considered in this review, and there may be different FSH cut offs depending on technique.[8] Although many of the studies described surgical techniques and gamete processing, variation is likely to be high. This mirrors global clinical practice, and so may not be a significant limitation to the results.

As previously highlighted, the vast majority of articles regarded NOA, which can bias the inferred application of FSH from this review. When the seven papers which included OA and mixed aetiologies are analysed separately, they are consistent with the existing literature:

males with OA have lower FSH and far higher successful SSR compared to males with NOA and higher FSH levels.[5,27,38] Little could be concluded from the remaining papers, as they either did not stratify FSH levels or SSR outcomes according to azoospermia classification.

The studies have varying criteria for successful SSR.[9,21] For example, one study[8] regarded success as retrieval of one sperm, which may be less clinically relevant for ICSI. Different studies used varying normal FSH ranges,[34,36] and so descriptions of 'high' or 'low' levels should be interpreted with caution.

Pregnancy and Birth Outcomes

The ultimate aim for SSR is to produce a healthy baby when combined with ICSI, so it is interesting that so few publications have considered these outcomes. Song et al.'s[40] research used FSH as part of a multivariable model, finding FSH significant in prediction of obtaining clinical pregnancy. This study was excluded from this review, as SSR had already occurred and was not the focus of the paper. Zitzmann et al.[35] identified 100% specificity for predicting no pregnancy or live births with FSH >20 IU/L (p=0.008). Meanwhile, alternative authors did not find FSH significant in predicting such outcomes.[24,31,38] Therefore the correlation between preoperative FSH in SSR, ICSI, and obstetric outcomes seems contested, and warrants further investigation.

Clinical Implication

It is well established that infertility is associated with feelings of disappointment and loss of control, independent of ethnicity and culture.[41] The included studies reflect the global scale and impact of azoospermia and SSR treatment. In addition to marked psychological burden, SSR confers similar risks to any surgical procedure: bleeding, infection, scarring, and associated hypogonadism,[42] which may further decrease spermatogenesis for repeat procedures.

Clinicians therefore have an ethical obligation when offering fertility treatment to couples, and not adopt a 'one size fits all' approach. If ICSI is likely to be futile for specific couples,[35] clinicians also have a duty to female partners as oocyte collection carries the previously stated risks in addition to ovarian hyperstimulation syndrome, which can be fatal.

Additional Authors' Perspective

This work differs from previous reviews, which have either solely focused on microsurgical techniques,[43] or the role of FSH in NOA SSR only.[44]

Additionally, this review summarises important inclusion and exclusion criteria, which may be utilised when providing evidence-based care to specific subsets of patients. Conversely the authors chose to cover all forms of SSR and azoospermia for generalisability of results for patients and clinicians, or where microsurgery may not be available.

CONCLUSION

The authors performed this review with an aim to determine if FSH values can be correlated with success of SSR and, if so, to define a cut off value. This will allow clinicians to counsel patients whether SSR with ICSI is likely to be efficacious, or if pursuing non-biological methods to achieve parenthood may be more appropriate. This review demonstrates that there is an association between lower serum FSH levels and increasingly successful SSR. The authors have not identified a discriminative FSH result to accurately predict SSR outcomes, although a suggested range of values were described. To further elucidate this link, the authors suggest future work should continue to focus on FSH used in combination with other endocrinological and clinical markers.

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