Full Length Research Article
Advancements in Life Sciences – International Quarterly Journal of Biological Sciences

ARTICLE INFO

Date Received: 21/06/2023;
Date Revised: 21/07/2023;
Date Published Online: 20/10/2023;

Authors' Affiliation:
1. College of medicine, University of Kufa - Iraq
2. Department of Urology/Clinical Embryology College of Medicine, University of Kufa - Iraq
3. College of Medicine, University of Babylon - Iraq
4. Infertility Center, Al-Sader Teaching Hospital - Iraq

***Corresponding Author:**
Ali Abo-Alshaar
Email:
alia.aboalshaar@student.uokufa.edu.iq

How to Cite:
Abo-Alshaar AA, Abdulkadim H, Mejbel WS, Ahmed RH (2023). Value of serum Inhibin B as a Prognostic Factor in Patients with Non-obstructive Azoospermia. Adv. Life Sci. 10S(1): 50-55.

Keywords:
Inhibin B; Non-obstructive azoospermia; Infertility; Testicular sperm extraction (TESE)

Open Access

Value of Serum Inhibin B as a Prognostic Factor in Patients with Non-obstructive Azoospermia

Ali A. Abo-Alshaar[1], Hind Abdulkadim[2], Walaa Saeb Mejbel[3], Raghad Hussein Ahmed[4]

Abstract

Background: Non-obstructive Azoospermia (NOA) mean absence of sperm in the ejaculate due to testicular failure. The sole treatment till now for them is testicular sperm retrieval and ICSI. There is no single test that can predict precisely the presence of sperm in testicular the testis. Several studies around the world hypothesized that testicular hormone especially inhibin B can make decision about the sperm retrieval. The objective of this study was to evaluate the efficacy of serum inhibin B level in non-obstructive azoospermia as predictor for sperm retrieval by using testicular sperm extraction (TESE).

Methods: This cross-sectional study carried out on 188 men with non-obstructive azoospermia. A detailed medical history, physical examination, age, duration of infertility and BMI was recorded. Men with obstructive azoospermia are excluded from the study. About 5 ml of venous blood taken from them to measure serum inhibin B, FSH, LH, Prolactin and Testosterone before doing testicular sperm retrieval.

Results: From the studied sample, (45.7%) were positive testicular sperm retrieval, while (54.3%) were negative sperm retrieval. the median level of INHB for the positive TESE was (54.7pg/ml) which is significantly higher than that for TESE negative (24pg/ml). With representation of INHB values on ROC curve, the sensitivity was 70.9% and specificity was 50% with cutoff 24 pg/ml.

Conclusion: Inhibin B is significantly higher in TESE positive patients but with not far enough sensitivity and specificity to predict the presence of sperm.

Introduction

It is estimated that 1% of men and 15% of the infertile men have azoospermia, the cause of azoospermia is either obstructive or non-obstructive [1]. Many factors responsible for male infertility including: testicular failure, genetic and chromosomal abnormalities, hormonal disturbances, varicocele, genital tract infection, retrograde ejaculation, smoking, alcohol, heavy metal, chemical and radiological exposure, nutritional and different environmental factors that directly or indirectly affect male fertility [2].Non obstructive azoospermia defined as absence of sperm despite the ideal amount of semen due to spermatogenic failure which regarded as the most severe form of male infertility [3]. Testicular sperm retrieval still the final hope for infertile men with NOA to be a biological father for their sibling and substitute the sperm donation. First pregnancy using surgically retrieved testicular sperm (TESE) from men with non-obstructive azoospermia (NOA) were reported in 1994 [4]. Sperm retrieval rate not exceed 60% in best situation [3,5].In recent years, non-invasive methods can predict spermatogenesis in patients with non-obstructive azoospermia (NOA) such as measurement of Inhibin B alone or in combination with other hormones [6].Inhibin B is a dimeric glycoprotein hormone secreted from Sertoli cells in response to FSH and act by negative feedback effect on FSH, the secretion of this hormone correlates with the degree of spermatogenesis [7-10].

Methods

This was observational cross-sectional study carried out on men with non-obstructive azoospermia due to primary testicular failure who seek for fertility treatment in the fertility center of "Alsader medical city", from July, 2022 to April, 2023.The studied sample include 188 men all of them are non-obstructive azoospermia and diagnosed by urologist according to history, clinical examination and investigation like seminal fluid analysis, hormonal profile (FSH, LH, Prolactin, Testosterone), and testicular size by ultrasound.The ages range was between (20-54) years with mean ± SD (33.4 ± 7.5) years, duration of infertility ranges from (1-30) years with mean ± SD (7.6 years ± 5.5) and BMI range (18.02-40.9) kg/m² with mean ± SD (26.6 kg/m² ± 4.7).Those patients are recruited for diagnostic and therapeutic testicular biopsy (TESE, microTESE or TESA) under spinal or general anesthesia for future fertility treatment by ICSI.In the morning of thesurgery a blood sample was taken from all patients at about (9 am-11am) followed by testicular sperm retrieval surgery.Men who diagnosed with obstructive azoospermia were excluded from the study.

Blood Samples Collection

For each participant 5 ml of venous blood collected from cubital vein into gel tube then left at room temperature for at least 30 minutes, then centrifuged at 1000×g force for 10 minutes to separate serum from the blood. The serum is transferred to Eppendorf tube by sterile pipette to be stored at a deep freezer (-80 °C) for future analysis of serum Inhibin B by ELISA system for all the participants in one time.

Testicular sperm retrieval by testicular Sperm Extraction (TESE)

The technique was performed under general or spinal anesthesia by urologist, all collected samples placed in petri dish containing sterile HEPES buffered media from Vitrolife® in the operating room then transferred to andrology lab. and mechanically minced by two curved needles in aseptic conditions in order to squeeze the spermatozoa out from the seminiferous tubules, no enzymes used in this technique, then make a wet preparation by taking 10 µl of the sample on glass slide and cover it by cover-slip then examined by light microscope (40x) for the judgment of presence of spermatozoa. If there is no sperm found in the 12 field the specimen is centrifuged (2000 rpm for 10 minutes) and check the pellet if no spermatozoa found in the pellet the specimen considered as negative for sperm.

INHB test principle

The ELISA kit from Elabscience® utilizes the Sandwich-ELISA principle. This kit does not require sample pretreatment. total incubation time of less than 2 hr. The micro-ELISA plate in this kit is pre-coated with an antibody specific to Human INHB. Samples are added to the micro-ELISA plate wells and combined with the specific antibody. Then a biotinylated finding antibody specific for Human INHB and Avidin-Horseradish Peroxidase (HRP) conjugate are added continuously to each micro-plate well and incubated. The optical density (OD) is measured spectrophotometrically at a wavelength of 450 nm ± 2 nm. The OD value is proportional to the concentration of Human INHB. The concentration of Human INHB is calculated in the samples by comparing the OD of the samples to the standard curve according to Walker and Crowther [11]. Data were reviewed and transferred into computerized database using statistical software; the statistical package for social sciences (SPSS). Descriptive statistics presented as frequencies (numbers), percentage (%), mean and standard deviation according to the variable type to compare two means of a variable, Student's t test for independent two groups were applied in variables that followed the normal statistical distribution, in variables that did not follow the statistical normal distribution, the non-parametric "Mann-Whitney" test was applied. All statistical

procedures and tests were performed under assumption of level of significance (P. value) of 0.05 or less to be significant difference or correlation.

Ethical consideration

All candidates accomplished an informed consent, reliable with the study protocol that was allowed by the institution ethical committee. The research was implemented according to the ideologies of the Helsinki Declaration.

Results

The studied sample included 188 men with primary infertility due to non-obstructive azoospermia. 45.7% (86) were positive for testicular sperm extraction surgery and 54.3% (102) were negative for the same procedure as shown in figure (1).

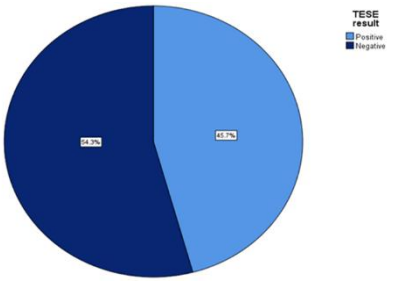


Figure 1: Pie chart represents TESE results in studied group.

Table (1) mean age in the TESE positive was 35.2±7.7 years which is significantly higher than that of TESE negative 31.7±7.1 years. Mean of duration of infertility in the TESE positive was 9.1±6.3 years which is significantly more than that of the TESE negative 6.4±4.3 years. No significant statistical difference in BMI between both groups.

Parameter	TESE result		P₮
	Positive (n=86) Mean±SD	Negative (n=102) Mean±SD	
Age (years)	35.2±7.7	31.7±7.1	0.002*
Duration of infertility (years)	9.1±6.3	6.4±4.3	0.001*
BMI (kg/m²)	26.8±3.7	26.5±5.3	0.8

*Significant₮: student t-test TESE: Testicular sperm extraction

Table 1: Comparison of mean age, duration of infertility and BMI according to TESE results.

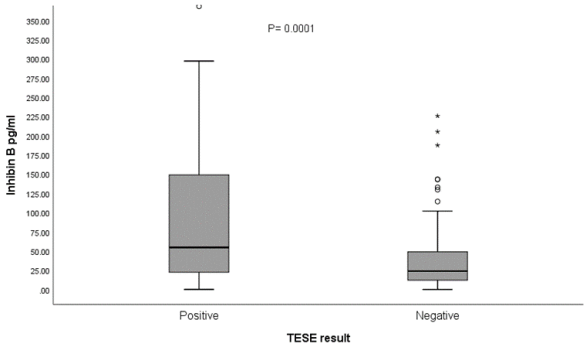
Regarding serum FSH, LH, Prolactin and testosterone, the median of their values compared according to TESE results in table (2). The values are represented as median and interquartile range. There is a significant statistical difference in FSH and LH level between both groups. while Prolactin and testosterone had no significant difference with TESE results.

The values of serum inhibin B are measured and compared for TESE positive and TESE negative groups. The median of INHB for TESE positive was (54.7pg/ml) which is significantly higher than median of TESE negative (24pg/ml) with P value=0.0001, figure (4.2) show that explanation.

Hormone	TESE result		P Ɱ
	Positive n=86 Median (IQR)#	Negative n= 102 Median (IQR) #	
FSH(mIU/ml)	5.1 (11.4)	20.1 (21.6)	0.0001*
LH (mIU/ml)	3.7 (2.8)	7.2 (8.02)	0.0001*
Prolactin (ng/ml)	8.2 (5.4)	9.3 (11.3)	0.1
Testosterone (ng/dl)	355.4 (202.7)	318.1 (393.02)	0.4

*Significant, #IQR: interquartile range, Ɱ: Mann-Whitney test
FSH: follicle stimulating hormone
LH: luteinizing hormone

Table 2: Comparison of FSH, LH, Prolactin and Testosterone according to TESE results.



* High extreme values ◦ High potential outliers

Figure 2: Whisker boxplot comparing median inhibin B (pg/ml) according to TESE results plotted as positive and negative results.

In figure (3): Receiver operating characteristic curve (ROC) shows the performance of serum inhibin B toward the better sensitivity by plotting the true positive rate(sensitivity) against false positive rate (1-specificity). The best cutoff point of serum INHB was 24 pg/ml give 70.9% sensitivity and 50% specificity.

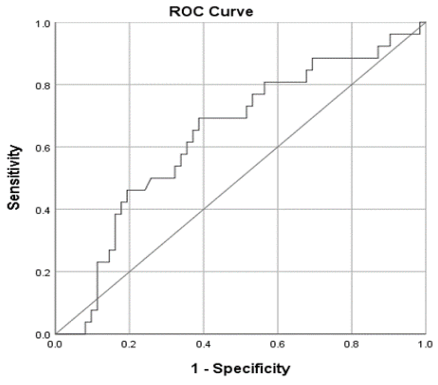


Figure 3: Receiver operating characteristic (ROC) curve of INHB.

Area Under the Curve				
Test Result Variable(s): Inhibin B pg/ml				
Area	Std. Error	*p* value	95% Confidence Interval	
			Lower Bound	Upper Bound
0.639	0.065	0.041*	0.511	0.766

Table 3: Detailed receiver operating characteristic (ROC) curve.

Table (4) explains the role of serum INHB (as a predictor) by cutoff value (24 pg/ml) as following: TP=61(70.9%), FN=51(50%), FP=25(29.1%), TN=51(50%). So, according to the equation TP/(TP+FN) sensitivity of the test is 70.9%, and by the equation TN/(TN+FP) the specificity of the test is 50%, with diagnostic accuracy 59%. (TP: true positive, FN: false negative, FP: false negative, TN: true negative). The values are represented as frequencies (numbers) and percentage (%)

		TESE result		Total
		Positive NO. (%)	Negative NO. (%)	
Inhibin B (pg/ml)	Positive	61 (70.9%)	51 (50%)	112 (59.6%)
	Negative	25 (29.1%)	51 (50%)	76 (40.4%)
Total		86 (100%)	102(100%)	188 (100%)

Table 4: Results of inhibin B test as predictor comparing to TESES results.

Discussion

The physiological importance of INHB is to express the negative feedback effect on FSH secretion, and as the spermatogenesis present, Sertoli cell function still present and inhibin still secreted by these cells [12]. The optimum level of INHB to assess male fertility whether fertile or non-fertile has not established till now [6].

The participants in this study were entered the testicular sperm retrieval surgery and the TESE was positive for 45.7%.In our study mean age of TESE positive was higher than mean of TESE negative i.e., sperm retrieval rate is higher in older age group, similar to Kizilkan *et al.,* [13], this is may be due to their exposure to a second biopsy which may increase the chance of sperm retrieval or a documentation to the hypothesis which stated that older men with NOA may have secondary azoospermia due to environmental or acquired factors with better biopsy outcome [14]. Duration of infertility in the TESE positive was significantly more than that in TESE negative (the more duration the more prediction for sperm retrieval), this is supported by Saccà *et al.,* [15] who found a positive correlation of duration of infertility with TESE results. El-Haggar *et al.,* [16], Kizilkan *et al.,* [13] and Ghalwash *et al.,* [17] found no statistically significant association between period of infertility and sperm retrieval. Regarding BMI, this study showed no significant statistical association between BMI and TESE result. This is supported by study conducted by Li *et al.,* [18]. *Iwatsuki et al.,* [19].

Our results showed that median of FSH was significantly lower in TESE positive (5.1 mIU/ml) than TESE negative (20.1 mIU/ml). Colpi *et al.,*[20], Ghalayini *et al.,* [21] and Amer *et al.,*[22] found a significant association between low FSH levels and positive sperm retrieval (FSH significantly lower in positive than negative TESE). Regarding LH, the median was significantly lower in TESE positive (3.7 mIU/ml) than median in TESE negative (7.2mIU/ml). Saber-Khalaf *et al.,* [23] showed significant lower LH and FSH in positive sperm retrieval group. Regarding prolactin, the median had no statistically significant difference according to TESE results (p value= 0.1), this is supported by study conducted by Salehi *et al.,* [24] who found neither prolactin nor testosterone are significantly differ according to testicular sperm retrieval rate. Regarding testosterone, the median had no statistically significant difference according to TESE results (p value= 0.4), this is supported by study conducted by Althakafi *et al.,* [25] who found no significant difference in testosterone level in relation with testicular sperm retrieval results. Güneri *et al.,* [26] support all our results regarding FSH, LH, prolactin and testosterone. This study showed that serum INHB level in TESE positive was significantly higher than that in TESE negative group (54.7 pg/ml versus 24pg/ml). Similar results present in study conducted by Al-Bdairi *et al.,* [27] and Gamidov *et al.,* [28]. Barbotin *et al.,* [29] showed no significant difference of INHB levels with TESE results in NOA but his study was only on cryptorchidism patients. In our study, INHB with cut off value 24 pg/ml had 70.9% (nearly 71%) sensitivity and 50% specificity, this was near to results obtained by Huang *et al.,* [30]. According to the above-mentioned data serum INHB is a supportive marker for the diagnosis with accepted level of sensitivity and specificity for sperm retrieval rate and has no accurate or conclusive predictive role for sperm recovery in male with non-obstructive azoospermia. Our result is supported by Tunc *et al.,* [31] who showed that INHB is not predictive for sperm retrieval with sensitivity 90% and specificity only 14%, Radkhah *et al.,* [32].

It's important to note that sensitivity and specificity of serum INHB can rise more if we compare NOA patients with OA group or normal control (for male fertility assessment), as conducted by Kong *et al.,* [33] who showed that 92% sensitivity and 88% specificity with INHB cut off 45.9 pg/ml when comparing obstructive and non-obstructive azoospermia, but this is not our aim in this study. In contrast, some studies such as Ballescá *et al.,* [34] made INHB as predictor for presence of sperm by TESE in NOA cases, with sensitivity 90%, specificity 100% (cut off >40 pg/ml). A systematic review done by Deebel *et al.,* [35] highlighted on role of INHB in predicting sperm retrieval in NOA with Klinefelter syndrome, showed that INHB cannot predict sperm retrieval.

Most of studies in the literature took both INHB and FSH as markers to either predict or not predict spermatogenesis of NOA patients. Al-Bdairi *et al.,* [26] concluded that both INHB and FSH are reliable

noninvasive markers to predict the outcome of sperm retrieval. Several researchers such as Deng *et al.,* [36] utilize both INHB and AMH as tool for sperm prediction as they are both testicular hormones and of Sertoli cell origin, the mentioned study found INHB/AMH ratio give promising results about sperm retrieval. Besides these conflicting data and the controversies about the "direct marker" role of serum Inhibin B in determination of spermatogenesis, it does not seem to give a clue about the presence of sperm before TESE, as focal spermatogenic activity is very little to have stimulatory effect on Sertoli cells to produce INHB. So INHB measurement can be used to reflect the function of testicular tissue in general, but cannot predict exactly the presence of sperm.

We suggest that serum INHB can be used as supportive test for counseling NOA patients instead of being an accurate marker for the presence or absence of sperm before doing TESE. Testicular biopsy and histopathology remain the cornerstone and gold standardmethod in diagnosing the presence or absence of focal spermatogenesis in NOA patients. Serum levels of Inhibin B hormone is significantly higher in TESE positive than TESE negative group. With a cut off 24pg/ml the sensitivity is 70.9% and specificity 50%, so Inhibin B is not far enough sensitive and specific to predict sperm retrieval and should not be used in clinical practice as marker to predict sperm retrieval.

Competing Interests

The authors declared that there were no conflictsof interest.

Author Contributions

AAA: Research idea, study design and manuscript, HA: Data collection and Data analysis, RHA: Interpreted the results, WSM: Logistic support. All authors discussed the findings and provided feedback on the text.

References

1. Tahmasebi-Birgani M. Commentary on Non-obstructive Azoospermia (NOA); From Past to the Present. Jentashapir Journal of Cellular and Molecular Biology, (2021); 12(1): e115298.
2. Naz M, Kamal M. Classification, causes, diagnosis and treatment of male infertility: a review. Oriental pharmacy and experimental medicine, (2017); 17:89-109.
3. Chiba K, Enatsu N, Fujisawa M. Management of non-obstructive azoospermia. Reproductive medicine and biology, (2016); 15: 165-73.
4. Devroey P, Liu J, Nagy Z, Tournaye H, Silber SJ, Van Steirteghem AC. Normal fertilization of human oocytes after testicular sperm extraction and intracytoplasmic sperm injection. Fertility and sterility, (1994); 62(3): 639-41.
5. Achermann AP, Pereira TA, Esteves SC. Microdissection testicular sperm extraction (micro-TESE) in men with infertility due to nonobstructive azoospermia: summary of current literature. International Urology and Nephrology, (2021); 53(11): 2193-210.
6. Jankowska K, Suszczewicz N, Rabijewski M, Dudek P, Zgliczyński W, Maksym RB. Inhibin-b and FSH are good indicators of spermatogenesis but not the best indicators of fertility. Life, (2022); 12(4): 511.
7. Manzoor SM, Sattar A, Hashim R, Khan FA, Younas M, Ali A, Dilawar M, Ijaz A. Serum inhibin B as a diagnostic marker of male infertility. Journal of Ayub Medical College Abbottabad, (2012); 24(3-4): 113-6.
8. Makanji Y, Zhu J, Mishra R, Holmquist C, Wong WP, Schwartz NB, Mayo KE, Woodruff TK. Inhibin at 90: from discovery to clinical application, a historical review. Endocrine reviews, (2014); 35(5): 747-94.
9. Wijayarathna RD, De Kretser DM. Activins in reproductive biology and beyond. Human reproduction update, (2016); 22(3): 342-57.
10. Kumar, A. and Sharma, M. Chapter 2 the prostate gland: Basics of human andrology. (2017), page 31. Springer.
11. Walker, J. M. and Crowther, J. R. chapter 2. The ELISA guidebook. (2009), In Series Methods in Molecular Biology, second edition. 9-37. Springer.
12. Clavijo RI, Hsiao W. Update on male reproductive endocrinology. Translational andrology and urology, (2018); 7(Suppl 3): S367.
13. Kizilkan Y, Toksoz S, Turunc T, Ozkardes H. Parameters predicting sperm retrieval rates during microscopic testicular sperm extraction in nonobstructive azoospermia. Andrologia, (2019); 51(11): e13441.
14. Ramasamy R, Trivedi NN, Reifsnyder JE, Palermo GD, Rosenwaks Z, Schlegel PN. Age does not adversely affect sperm retrieval in men undergoing microdissection testicular sperm extraction. Fertility and sterility, (2014); 101(3): 653-5.
15. Saccà A, Pastore AL, Roscigno M, Naspro R, Pellucchi F, Fuschi A, Maruccia S, Territo A, Pisano F, Zanga L, Capitanio E. Conventional testicular sperm extraction (TESE) and non-obstructive azoospermia: is there still a chance in the era of microdissection TESE? Results from a single non-academic community hospital. Andrology, (2016); 4(3): 425-9.
16. El-Haggar S, Mostafa T, Abdel Nasser T, Hany R, Abdel Hadi A. Fine needle aspiration vs. mTESE in non-obstructive azoospermia. International journal of andrology, (2008); 31(6): 595-601.
17. Ghalwash MA, Ragab MM, Gamil TA, Mashaly MH. Prognostic Factors for Successful Microdissection Testicular Sperm Extraction (Micro-TESE). Journal of Advances in Medicine and Medical Research, (2021); 33(16): 30-5.
18. Li F, Yang Q, Shi H, Xin H, Luo X, Sun Y. Effects of obesity on sperm retrieval, early embryo quality and clinical outcomes in men with nonobstructive azoospermia undergoing testicular sperm aspiration-intracytoplasmic sperm injection cycles. Andrologia, (2019); 51(6): e13265.
19. Iwatsuki S, Sasaki S, Taguchi K, Hamakawa T, Mizuno K, Okada A, Kubota Y, Umemoto Y, Hayashi Y, Yasui T. Effect of obesity on sperm retrieval outcome and reproductive hormone levels in Japanese azoospermic men with and without Klinefelter syndrome. Andrology, (2017); 5(1): 82-6.
20. Colpi GM, Colpi EM, Piediferro G, Giacchetta D, Gazzano G, Castiglioni FM, Magli MC, Gianaroli L. Microsurgical TESE versus conventional TESE for ICSI in non-obstructive azoospermia: a randomized controlled study. Reproductive biomedicine online, (2009); 1;18(3):315-9.
21. Ghalayini IF, Al-Ghazo MA, Hani OB, Al-Azab R, Bani-Hani I, Zayed F, Haddad Y. Clinical comparison of conventional testicular sperm extraction and microdissection techniques for non-obstructive azoospermia. Journal of Clinical Medicine Research, (2011); 3(3):124.
22. Amer MK, Ahmed AR, Abdel Hamid AA, GamalEl Din SF. Can spermatozoa be retrieved in non-obstructive azoospermic patients with high FSH level?: A retrospective cohort study. Andrologia, (2019); 51(2): e13176.

23. Saber-Khalaf M, Ali AF, Elsoghier OM. Predictive factors of successful testicular sperm extraction for non-obstructive azoospermia with a history of bilateral cryptorchidism and normal testosterone. Andrologia, (2022); 54(1): e14284.
24. Salehi P, Derakhshan-Horeh M, Nadeali Z, Hosseinzadeh M, Sadeghi E, Izadpanahi MH, Salehi M. Factors influencing sperm retrieval following testicular sperm extraction in nonobstructive azoospermia patients. Clinical and experimental reproductive medicine, (2017); 44(1): 22.
25. Althakafi SA, Mustafa OM, Seyam RM, Al-Hathal N, Kattan S. Serum testosterone levels and other determinants of sperm retrieval in microdissection testicular sperm extraction. Translational andrology and urology, (2017); 6(2): 282.
26. Güneri Ç, Alkibay T, Tunç L. Effects of clinical, laboratuary and pathological features on successful sperm retrieval in non-obstructive azoospermia. Turkish Journal of Urology, (2016); 42(3): 168.
27. Al-Bdairi A, Al-Hindy HA, Al-Shalah MA. Preoperative Measures of Serum Inhibin B, and FSH Levels Predict Sperms Retrieval Outcome in Non-Obstructive Azoospermic Males. Clinical Schizophrenia & Related Psychoses, (2021); 6; 15.
28. Gamidov S, Shatylko T, Popova A, Gasanov N, Sukhikh G. Azoospermic men with isolated elevation of follicle-stimulating hormone represent a specific subpopulation of patients with poor reproductive outcomes. Clinical and Experimental Reproductive Medicine, (2022); 49(1): 62.
29. Barbotin AL, Dauvergne A, Dumont A, Ramdane N, Mitchell V, Rigot JM, Boitrelle F, Robin G. Bilateral versus unilateral cryptorchidism in nonobstructive azoospermia: testicular sperm extraction outcomes. Asian Journal of Andrology, (2019); 21(5): 445.
30. Huang X, Bai Q, Yan LY, Zhang QF, Geng L, Qiao J. Combination of serum inhibin B and follicle-stimulating hormone levels can not improve the diagnostic accuracy on testicular sperm extraction outcomes in Chinese non-obstructive azoospermic men. Chinese Medical Journal, (2012); 125(16): 2885-9.
31. Tunc L, Kırac M, Gurocak S, Yucel A, Kupeli B, Alkıbay T, Bozkirli I. Can serum Inhibin B and FSH levels, testicular histology and volume predict the outcome of testicular sperm extraction in patients with non-obstructive azoospermia?. International urology and nephrology, (2006); 38: 629-35.
32. Radkhah K, Nourouzi M, Ayati M, Jamshidian H, Ranjbaran A, Jabalameli P. Serum inhibin B concentration as a prognostic factor for prediction of sperm retrieval in testis biopsy of patients with azoospermia. Archives of Iranian medicine, (2008); 11(1): 54-56
33. Kong X, Ye Z, Chen Y, Zhao H, Tu J, Meng T, Xiong C, Li H, Gong Y, Zheng L, Cheng B. Clinical application value of Inhibin B alone or in combination with other hormone indicators in subfertile men with different spermatogenesis status: A study of 324 Chinese men. Journal of Clinical Laboratory Analysis, (2021); 35(8):e23882.
34. Ballescá JL, Balasch J, Calafell JM, Alvarez R, Fábregues F, de Osaba MJ, Ascaso C, Vanrell JA. Serum inhibin B determination is predictive of successful testicular sperm extraction in men with non-obstructive azoospermia. Human Reproduction, (2000); 15(8):1734-8.
35. Deebel NA. Galdon G, Zarandi NP, Stogner-Underwood K, Howards S, Lovato J, Kogan S, Atala A, Sadri-Ardekani H. Age-related presence of spermatogonia in patients with Klinefelter syndrome: a systematic review and meta-analysis. Human Reproduction Update, (2020); 26(1): 58-72.
36. Deng C, Liu D, Zhao L, Lin H, Mao J, Zhang Z, Yang Y, Zhang H, Xu H, Hong K, Jiang H. Inhibin B-to-Anti-Mullerian Hormone Ratio as noninvasive predictors of positive sperm retrieval in idiopathic non-obstructive azoospermia. Journal of Clinical Medicine, (2023); 12(2):500.