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Triptorelin acetate in pediatric endocrinology: A retrospective analysis of treatment outcomes and long-term efficacy

Sondos Barjas Harahshih *, Fadi Farhan Ayyash, Hadeel Othman Alqurieny, Waed Mahmoud Itewi, Ahmad Amer Ali Al Hajieh, Abdelrazaq Ahmad Alyasin and Dana Wahib Mohammad Almansour

Department of Pediatric Endocrinology, Queen Rania Abdallah Hospital for Children, King Hussein Medical Center, Royal Medical Services, Amman, Jordan.

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Abstract

Aims: This study aims to evaluate triptorelin acetate's efficacy in suppressing pubertal progression and stabilizing bone age advancement in Jordanian children with Central Precocious Puberty (CPP). It will also monitor regression of secondary sexual characteristics, evaluate bone age progression relative to chronological age, and assess improvements in predicted adult height. The study will provide insights into the real-world effectiveness of triptorelin acetate in a Middle Eastern pediatric population, guiding clinicians in tailoring treatment protocols and stratifying patients for optimal response. The findings may also inform future monitoring and follow-up strategies for children undergoing GnRH agonist therapy.

Methods: The study analyzed the medical records of 79 children treated with medication at Queen Rania Abdallah Hospital for Children from January 2023 to December 2024. The children had to meet certain criteria, including being at least 13 years old, having a confirmed diagnosis of CPP, and having complete baseline and follow-up data. The data set included information about age, gender, and BMI, as well as clinical parameters like growth rate and pubertal staging. Hormonal tests were conducted to monitor puberty progression, and the Greulich-Pyle approach was used to evaluate bone age. Written information about the therapy was also collected. Statistical analysis was performed to identify useful information, using means, rates, paired t-tests, Wilcoxon signed-rank tests, multivariate regression analysis, and ROC curve analysis. A power of 80% was used to ensure clinically meaningful effects, and a p-value of less than 0.05 was considered statistically significant. The data was stored using conventional statistical programs.

Results: A study on Central Premature Puberty in children found that triptorelin acetate effectively blocked gonadotropins, reducing levels of LH and FSH in 92.4% of patients. The treatment also decreased levels of FSH and sex steroids, indicating hormones' role in puberty regulation. Post-treatment, children's projected adult height (PAH) grew by an average of +4.2 ± 1.7 cm, and the bone age to chronological age ratio was significantly reduced. Younger age at the start and longer treatment period were significant indicators of better outcomes for PAH. The recommended cutoff age for the greatest treatment response was ≤8 years, emphasizing the need for early detection and treatment of CPP. Triptorelin acetate is generally well-tolerated with no notable side effects.

Conclusion: Research shows triptorelin acetate can slow bone ageing, prevent puberty, and improve PAH in children as young as eight years old. However, more long-term studies are needed to determine its predictive characteristics and long-term results. Despite no damage found, the current CPP recommendations for early therapy for GnRHa are more credible.

Keywords: Triptorelin acetate; Central precocious puberty; Pediatric endocrinology; GnRH agonist; Treatment outcomes; Jordan

* Corresponding author: Sondos Barjas Harahshih

1. Introduction

Central precocious puberty (CPP) is characterized by the premature activation of the Because of the hypothalamic-pituitary-gonadal (HPG) axis, secondary sexual characteristics begin to develop in girls before the age of eight, whereas they begin to develop in boys before the age of nine. This illness is brought on by the early pulsatile release of gonadotropin-releasing hormone, also known as GnRH. In order for the pituitary gland to produce luteinizing hormone (LH) and follicle-stimulating hormone (FSH), the pituitary gland is instructed to do so by GnRH. Gonadal steroids are produced as a result of the presence of these hormones. Congenital pulmonary pyochondritis can result in psychological and social issues due to early physical development, a shorter adult height due to the epiphyseal closure occurring too soon, and possibly long-term metabolic and cardiovascular concerns (3,4). If the condition is not treated, it can lead to these issues.

Gonadotropin-releasing hormone (GnRH) agonists, such as triptorelin acetate (5), are the most effective treatment for chronic polycystic ovary syndrome (CPP). An increase in the release of gonadotropins is the first step that these medications take in order to reduce the production of sex steroids. After this, there is a constant downregulation of receptors, which ends the production of luteinizing hormone and follicle stimulating hormone (6). Long-acting triptorelin acetate, when injected into or under the skin, has been demonstrated in a number of studies to be effective in preventing the onset of puberty, delaying the process of bone ageing, and increasing the predicted adult height (PAH) (7,8).

In spite of the fact that GnRH agonists are frequently used in CPP, there is a paucity of knowledge regarding how they function over the protracted period of time, particularly in individuals from the Middle East (9). Studies that concentrate on a particular region are required in order to improve the efficacy of therapy. This is because elements such as genetics, diet, and the environment can all have an impact on how effectively a treatment works (10). Having regional clinical statistics is considerably more significant than it already was because of the disparities in drug formulations, dose schedules, and monitoring mechanisms that exist between regions (11).

There has been a significant amount of research conducted on triptorelin acetate in populations from the West and East Asia; however, there is a lack of information regarding the safety and effectiveness of the medication in Jordanian youngsters 12. Due to the fact that the majority of research have only focused on short-term outcomes, there is a lack of knowledge regarding the mechanism of action of hormone reduction, its impacts on the body over the long term, and the factors that may be utilised to forecast how effectively a treatment would be effective (13). among addition, there has not been a sufficient amount of research conducted on the effects of GnRH agonist treatment on metabolic parameters, mental health, and adult height among persons who are from the Middle East (14).

For the purpose of filling in these gaps, this study investigates the efficacy, safety, and growth potential of triptorelin acetate in children diagnosed with chronic pulmonary hypertension in Jordan. By examining pubertal suppression, bone age development, projected adult height, and side effects, this study will assist us in gaining a better understanding of how to provide the most effective treatment for this particular set of individuals.

The following are the primary and intermediate objectives that this study intends to accomplish: It is important to determine the degree to which triptorelin acetate is able to prevent the onset of puberty and the alteration of bone age over time. Keeping an eye on the Tanner stages of secondary sexual traits is important in order to determine whether or not they are deteriorating or remaining the same. Determine the degree to which the bone age is slowing down according to the chronological age of the individual. Enquire about the impact that the modifications will have on PAH. Assessing the levels of PAH both before and after treatment can be accomplished by the utilisation of well-known growth prediction methods such as the Bayley-Pinneau or Tanner-Whitehouse methodologies. It is important to investigate the consequences that arise when hormones such as oestrogen, luteinizing hormone, and follicle-stimulating hormone are inhibited.

Check the levels of luteinizing hormone (LH), follicle stimulating hormone (FSH), oestradiol (in women), and testosterone (in men) in the blood throughout and after treatment. If it is necessary, you can perform GnRH activation tests in order to determine whether or not the hormone suppression is sufficient. Please make sure that you do not forget about the risks and adverse consequences. It is important to keep a record of any adverse reactions that occur either immediately or later on, such as swelling at the injection site, an increase in appetite, or transformations in your metabolism. You should be on the lookout for peculiar problems such as allergic responses or pseudotumor cerebri. Determine the factors that will demonstrate the most favourable response to support. Some of the things that should be looked into as potential markers of how effectively a treatment is functioning include growth speed, bone age delay, and baseline hormone levels. These are just some of the things that should be considered. Determine whether or whether

there is a connection between the outcome of the treatment and biological parameters (such as body mass index or age at the beginning of treatment).

With the help of this study, we will be able to gain a better understanding of the efficacy of triptorelin acetate in the real world, specifically in a group of children from the Middle East, where the genetic and environmental factors may be different from those in other groups (15). As a result of the fact that the findings of this study are pertinent to the field of paediatrics in Jordan, there will be an improvement in the way that medical professionals treat children who have CPP. In order to make more efficient use of resources and reduce the number of interventions that are not essential, it would be beneficial to discover markers that indicate how effectively GnRH agonist therapy would work. This would allow patients to be categorised according to the amount of potential benefit (16). Additionally, this study contributes to the existing body of knowledge regarding the management of CPP in different parts of the world. This is an essential contribution to paediatric endocrinology research that focusses on specific populations. It is possible that these findings will be useful in guiding future suggestions regarding the most effective methods to monitor children who come from similar backgrounds and are receiving treatment with GnRH agonists (17).

2. Methods

The purpose of this research was to investigate whether or not triptorelin acetate was both safe and effective in the treatment of children who were diagnosed with central precocious puberty (CPP). The study focused on a group of children who had been treated with the medication at Queen Rania Abdallah Hospital for Children. A comprehensive analysis of the medical records of all 79 children was carried out. From January 2023 to December 2024, these individuals received medical attention. Ages varied from two to thirteen years old. Individuals who were interested in taking part in the research were required to fulfil a number of prerequisites. This meant that the individual had to be at least 13 years old when treatment began, have a confirmed diagnosis of CPP (which was discovered by clinical screening and biochemical verification of gonadotropin-dependent puberty), and have complete baseline and follow-up data (with fewer than 5% missing values). Each of these requirements was necessary in order to be eligible for treatment. It was determined that patients who did not fulfil the selection criteria were either not following the directions for treatment that were given to them by their physicians, had medical records that were missing more than five percent of the data, or were at least fifteen years old.

For the purpose of determining whether or not the therapies were successful, a large number of different items were included in the data set. There were a number of fundamental pieces of information that were gathered about each individual, including their age, gender, and body mass index (BMI). Clinical parameters such as growth rate, pubertal staging (Tanner classification), and other comparable measures were evaluated both at the beginning of the study and at subsequent follow-ups with the participants. A series of hormonal tests were carried out in order to monitor the biological suppression of puberty progression. The levels of luteinizing hormone (LH), follicle-stimulating hormone (FSH), oestradiol (for females), and testosterone (for males) were measured and analysed. The Greulich-Pyle approach was used in order to conduct a bone age evaluation in order to determine the extent to which skeletal growth was associated with treatment responsiveness. There was also written information regarding the therapy itself, such as the amount of triptorelin acetate that was administered, how often it was administered, and for how long it was administered. During the course of the trial, each and every adverse effect that was seen was meticulously documented in order to facilitate the assessment of the medication's safety.

To discover information that was helpful, statistical analysis was performed on the data that was obtained. To provide a comprehensive summary of the beginning characteristics and treatment outcomes, the means plus or minus the standard deviations (SD) were used for continuous variables, while rates were utilised for categorical variables of various sorts. When comparing hormone levels, growth rate, and bone age development before and after therapy, we utilised paired t-tests for normally distributed data and Wilcoxon signed-rank tests for non-parametric data. Both of these tests were considered to be statistically significant. We employed multivariate regression analysis to uncover probable markers of treatment effectiveness by taking into consideration elements that may be cause for confusion. These factors included the individual's age at the beginning of therapy, their starting hormone levels, and their body mass index (BMI). In addition, a receiver operating characteristic (ROC) curve analysis was carried out in order to determine the optimal age limit for getting a positive response to therapy. In order to ensure that clinically meaningful effects might be discovered, a power of 80% was used, and a p-value of less than 0.05 was regarded as statistically significant. We ensured that the data may be used once again by using conventional statistical programs such as SPSS or R for each and every one of our calculations.

The objectives of the research were to determine the elements that influence the results of treatment and to offer information that is supported by data on the effectiveness of triptorelin acetate in lowering CPP in real-world situations. A rigorous scientific approach was used in order to accomplish these objectives.

3. Results

The average age of the children who were treated with triptorelin acetate at Queen Rania Abdallah Hospital for Children was 7.8 years old. CPPP, which stands for central premature puberty, was determined to be the condition. The fact that 86.1% of the participants were female (n = 68) demonstrates that girls are more likely to have CPP than boys. It may be inferred that the average body mass index (BMI) of the group was 18.4 ± 2.1 kg/m2, which indicates that its members initially had a weight that was quite normal.

Table 1 Baseline Characteristics of the Study Cohort (N = 79)

Variable	Mean ± SD / n (%)
Age (years)	7.8 ± 1.5
Gender (Female)	68 (86.1%)
BMI (kg/m^2)	18.4 ± 2.1
Baseline LH (IU/L)	4.2 ± 1.8
Baseline FSH (IU/L)	3.5 ± 1.2
Bone Age Advancement (years)	2.1 ± 0.9

Legend: BMI: Body mass index; LH: Luteinizing hormone; FSH: Follicle-stimulating hormone; Data presented as mean ± standard deviation (SD) for continuous variables and n (%) for categorical variables.

Table 2 Hormonal and Auxological Outcomes After 6 Months of Triptorelin Acetate Treatment

Outcome Measure	Baseline (Mean ± SD)	6-Month Follow-up (Mean ± SD)	p-value
LH (IU/L)	4.2 ± 1.8	0.2 ± 0.1	<0.001
FSH (IU/L)	3.5 ± 1.2	0.8 ± 0.3	<0.001
PAH Improvement (cm)	–	+4.2 ± 1.7	<0.001
ΔBA/CA Ratio	1.7 ± 0.4	1.3 ± 0.3	0.003

Legend: PAH: Predicted adult height; ΔBA/CA: Bone age to chronological age ratio; $p < 0.05$ considered statistically significant (paired t-test/Wilcoxon signed-rank test).

Table 3 Predictors of Treatment Response in Multivariate Regression Analysis

Predictor Variable	β-coefficient	95% CI	p-value
Age at Initiation (years)	-0.42	-0.61 to -0.23	0.01
Treatment Duration (months)	0.38	0.15 to 0.61	0.02

Legend: β: Standardized regression coefficient; CI: Confidence interval; Model adjusted for baseline LH, BMI, and sex.

Table 4 Adverse Effects Observed During Triptorelin Acetate Therapy

Adverse Effect	Frequency, n (%)
Injection-site reactions	10 (12.7%)
Headaches	7 (8.9%)
Mood changes	4 (5.1%)
Severe adverse events	0 (0%)

Legend: All adverse events were mild and transient; none led to treatment discontinuation.

An overall measurement of 4.2 ± 1.8 international units per litre (IU/L) of luteinizing hormone (LH) and 3.5 ± 1.2 IU/L of follicle-stimulating hormone (FSH) was taken at the beginning of the study. As shown by this, puberty cannot take place in the absence of gonadotropins. Based on the Greulich-Pyle approach, our findings indicate that the progression of bone age is 2.1 0.9 years beyond the age at when the bones were first discovered. According to the pattern of CPP, which is marked by faster skeletal development, this is consistent with the pattern.

In the process of preventing puberty, it was discovered that triptorelin acetate is an effective technique. After six months of therapy, the levels of LH were reduced to less than 0.3 IU/L in 92.4% of patients (n = 73), indicating that the medicine was successful in blocking gonadotropins. The results showed that the medication was effective in blocking gonadotropins. Furthermore, in a similar vein, the levels of follicle stimulating hormone (FSH) and sex steroids (oestradiol in females and testosterone in boys) were significantly decreased when compared to the original level ($p < 0.001$). It seems that hormones play a significant part in the regulation of puberty.

During CPP treatment, one of the primary goals is to ensure that the individual's potential for development is maintained. The study findings indicate that after receiving treatment, the children's projected adult height (PAH) grew by an average of +4.2 ± 1.7 cm ($p < 0.001$). These findings provide further proof that triptorelin acetate is an effective method for preventing the growth plates from closing prematurely earlier than expected. Furthermore, it is worth noting that the bone age to chronological age ratio (BA/CA) had a significant reduction ($p = 0.003$), which suggests that the treatment had a retarding effect on the development of the skeletal system. Evidence such as these lends credence to the hypothesis that GnRH analogues could be able to aid children with CPP in reaching their highest possible adult height potential.

By using multivariate regression analysis, we were able to determine the factors that have an effect on the effectiveness of the treatment. According to the data, two significant factors that were shown to be strong indicators of better outcomes for PAH were a younger age at the beginning of therapy ($\beta = -0.42$, $p = 0.01$) and a longer treatment period ($\beta = 0.38$, $p = 0.02$). When dealing with CPP, it is essential to seek assistance at an early stage and to maintain treatment for an extended period of time in order to get the best possible height results. Receiver operating characteristic analysis, often known as ROC analysis, was the method that the researchers used in order to ascertain the most appropriate age at which to begin treatment. According to the findings of the study, the area under the curve (AUC) was 0.82, which indicates that the predictions accurately reflected the data. Considering that the recommended cutoff age for the greatest treatment response was ≤8 years, this underscores the need of rapidly detecting and treating cognitive processing disorder (CPD).

The use of triptorelin acetate was generally well tolerated, and there were no notable side effects that were documented throughout its administration. These negative effects were experienced the majority of the time: The injection site may experience adverse effects, such as a little inflammatory response or pain. Headaches were experienced by 8.9% of the individuals; these headaches were often light, brief, and uncomplicated. A total of fifty-one percent of those who participated in the survey reported experiencing mood swings, which may include moderate anger or emotional instability. These data prove that the information that was previously known regarding the safety of GnRH analogues is correct. Triptorelin acetate is an outstanding choice for CPP treatment, according to the findings, which indicate that it is an excellent alternative.

On average, around 92.4 percent of patients were successful in bringing their LH levels down to less than 0.3 IU/L over a period of six months. The pace of bone age development was slowed down, and the PAH improved by an average of 4.2 centimetres. This is a significant improvement in growth. One of the Best Methods for Beginning Therapy Those who were less than eight years old were the most accurate group (area under the curve = 0.82). An excellent safety profile was shown by the fact that only a small number of mild, temporary side effects were identified. According to all of these

data, treating CPP with triptorelin acetate is a safe and successful alternative. This is especially true when the medication is provided early on and for a prolonged length of time in order to optimise the auxological effects.

4. Discussion

The objective of this study was to evaluate the effectiveness and safety of triptorelin acetate as a treatment for central precocious puberty (CPP) in a group of seventy-nine children and adolescents ranging in age from two to thirteen years old. Our results, which are in line with those of earlier research, indicate that GnRHa significantly reduced hormone levels, increased projected adult height (PAH), and exhibited a good safety profile. When the facts are considered in their current state, however, there are a few significant difficulties that need more examination.

Ninety-two point four percent of the people who took part in our study had brought their levels of LH down to less than 0.3 IU/L by the time the sixth month was over. This is consistent with the findings of earlier studies that shown that the administration of GnRHa led to the effective cessation of pubertal development in CPP [15, 16]. Triptorelin was demonstrated to lower rates by 89% in a European study that included 120 persons [17], suggesting that our results are supported by this evidence. In a similar manner, leuprolide acetate is a another GnRHa [18] that Carel et al. (2009) found to suppress LH in children by over 90 percent. A more limited study conducted by Lee et al. (2020) with a sample size of 32 participants only revealed a 78% reduction after a period of six months. This might be attributed to variations in the sensitivity of the test or the number of people who really began taking their medicine [19].

Further evidence supporting the effectiveness of triptorelin is the statistically significant reduction in both follicle stimulating hormone (FSH) and sex steroids ($p < 0.001$). According to Antoniazzi et al. (2010), who also noticed a drop in testosterone and oestradiol [20], the results are consistent with those of the studies presented here. Compared to past study that used leuprolide, our group observed a more rapid decrease in LH. This is something that should be taken into consideration. There is a possibility that triptorelin has a greater binding preference, which might explain this effect [21].

CPP therapy places a key emphasis on preserving the child's capacity for development as a primary primary focus. According to Luo et al. (2021), the average improvement in the PAH of our patients was 4.2 centimetres ($p < 0.001$). This finding is consistent with the findings of their meta-analyses, which suggested improvements of 3.5 to 5 centimetres with GnRHa [22]. Our ROC study [23] at the ideal age of 8 years, with an area under the curve of 0.82, is in agreement with Klein et al. (2021), who found that height advances became less noticeable beyond the age of 8.

What Brito et al. (2019) revealed, namely that bone age progression is slowed down, is analogous to the discovery that GnRHa slowed down skeletal development by 1.5 to 2 years (ΔBA/CA ratio, $p=0.003$). This data indicates that bone age progression is in fact slowed down. On the other hand, it is possible that treatment started later (mean age 9.1 years) in a longitudinal study that included 150 persons in the Netherlands. This might be the reason why there was a somewhat less apparent delay in bone age (BA/CA = 0.8 years) [25].

In order to forecast the improvement of PAH, our regression analysis indicated that a shorter treatment time ($\beta=0.38$, $p=0.02$) and a younger age ($\beta = -0.42$, $p=0.01$) were identified as relevant predictors. Magiakou et al. (2006) found that children who were treated before the age of seven saw larger height increases [26]. This conclusion is consistent with the findings of the aforementioned researchers. In contrast, a Korean study (n=95) [27] found that body mass index (BMI) and early low birth weight (LH) were more accurate indicators than age. This finding demonstrates that there are differences across populations.

In line with the findings of other studies [28], we found that 12.7% of the participants had injection site reactions, and 8.9% of them reported experiencing headaches. Both of these adverse events were considered to be very moderate. In contrast to the findings of leuprolide research [29], which reported a minuscule number of cases of anaphylactic responses (less than one percent), there were no significant occurrences that took place. The fact that mood transitions happened less often in European study (5.1% vs 12%) [30] may be explained by the possibility of cultural variations in the manner in which people describe experiences [31].

There is a possibility of selection bias while using retroactive planning method. Due to the single-center cohort design, the degree of application is restricted. A short follow-up was carried out after just twenty-four months had passed. To have a better understanding of the impacts that height has throughout the course of time, further research is necessary.

5. Conclusion

According to the findings of our research, triptorelin acetate has the ability to dramatically slow down the process of bone ageing, put a stop to the start of puberty, and improve PAH when it is given to children as early as eight years old. Additionally, additional long-term studies are necessary to discover which characteristics are predictive of response and long-term results. This is despite the fact that there has been no indication of damage found. The current CPP recommendations, which urge beginning therapy for GnRHa at an early stage, are given more credibility as a result of these results.

Compliance with ethical standards

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Disclosure of conflict of interest

There is no conflict of interest in this manuscript

Statement of ethical approval

There is no animal subject involvement in this manuscript. The Jordanian Royal Medical Services (JRMS) Institutional Review Board (IRB) initially approved this study at 3 June 2025 with the registration number 1_7/2025. This approved study was formally cleared for publishing after being reviewed by our institution's directorate of professional training and planning at 23 June 2025.

Statement of informed consent

Owing to the retrospective design of this study, the informed consent form was waived.

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