



Unveiling The Melody Of Transformation: A Harmonious Symphony Of Surgical And Non-Surgical Methods For Transgender Vocal Feminization For Pitch Elevation - A Systematic Review

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Abstract:

Objective: Voice feminization is a complex and comprehensive process for transgender population seeking to align their voice with their gender identity. While pitch elevation is often considered a primary goal, many surgical and non-surgical interventions have focused solely on this aspect of voice feminization. This systematic review aims to explore the efficacy of feminizing voice therapy and phono surgery in improving vocal pitch for transgender population.

Methods: A systematic review and meta-analysis were performed using Sagepub, Elsevier, Dovepress, EBSCOhost, PubMed, and Google Scholar with terms related to transgender phonosurgery, voice feminization, vocal pitch, and voice therapy. The inclusion criteria encompassed studies focusing on transgender individuals undergoing feminizing voice therapy or phono surgery for vocal pitch improvement. The selected studies were assessed for their quality and relevance, and data were extracted for analysis.

Results: Twenty-five articles were identified. After applying inclusion and exclusion criteria, a total of 12 studies were included in the meta-analysis. Post-operatively patient satisfaction was approximately 70% to 75% for voice therapy, Wendler's glottoplasty, and endoscopic shortening. F0 increasing – Wendler's glottoplasty > Endoscopic shortening > cricothyroid approximation > Voice Therapy > Laser Reduction glottoplasty.

Conclusion: The literature supports both voice therapy and phonosurgery, depending on a patient's magnitude of desired pitch change and tolerance for cost and potential complications. Most will likely benefit from voice therapy, as it is highly satisfactory, raises vocal pitch, and is non-invasive. However, Wendler's glottoplasty modified by Hagen and Endoscopic shortening provides viable options for individuals seeking to enhance their vocal pitch while maintaining voice quality. If surgery is chosen, postoperative voice therapy may additionally increase F0, stabilize the voice, and increase the vocal pitch. However, further research is warranted to explore the necessity to provide definitive clinical recommendations.

This study has been undertaken to investigate the determinants of stock returns in Karachi Stock Exchange (KSE) using two assets pricing models the classical Capital Asset Pricing Model and Arbitrage Pricing Theory model. To test the CAPM market return is used and macroeconomic variables are used to test the APT. The macroeconomic variables include inflation, oil prices, interest rate and exchange rate. For the very purpose monthly time series data has been arranged from Jan 2010 to Dec 2014. The analytical framework contains.

Index Terms - transgender phonosurgery, vocal feminization, voice therapy, vocal pitch, surgical and non-surgical method.

I. INTRODUCTION

Voice feminization is a multifaceted process that encompasses various interventions aimed at aligning the voice of transgender individuals with their gender identity. While increasing vocal pitch is commonly emphasized as a key objective, it is important to recognize that achieving a truly feminine voice involves more than pitch alone. Nevertheless, both surgical and non-surgical approaches have predominantly concentrated on pitch elevation as a primary focus of voice feminization interventions.

This systematic review seeks to delve into the effectiveness of feminizing voice therapy and phono surgery in enhancing vocal pitch for the transgender population. By systematically examining existing research studies, the review aims to provide a comprehensive analysis of the outcomes and efficacy of these interventions. It aims to go beyond a narrow focus on pitch elevation and explore other aspects of voice feminization, such as resonance, articulation, and prosody.

By synthesizing the available evidence, the review aims to shed light on the most effective techniques and approaches for achieving desired vocal pitch changes in transgender individuals. Additionally, it aims to identify potential gaps in current knowledge and areas for further research and development in the field of voice feminization. There are different options available for individuals seeking vocal feminization. These include both surgical and non-surgical approaches. One non-surgical option is voice therapy, which involves a series of sessions aimed at teaching patients how to use their voice in a manner that aligns with their identified gender. Voice therapy has been found to be effective in raising the pitch of the speaking voice, enhancing patient satisfaction, and improving externally-rated vocal femininity. Unlike phonosurgery, voice therapy also focuses on addressing non-pitch related aspects of vocal femininity.

Phonosurgery techniques for vocal feminization include cricothyroid approximation, endoscopic shortening, and laser reduction glottoplasty. Recent systematic reviews have shown that all three techniques effectively raise pitch, increase patient satisfaction, and enhance externally-rated vocal femininity. Endoscopic shortening achieves the largest increase in fundamental frequency (F0), indicating the greatest impact on pitch. It is important to consult with specialized healthcare professionals to determine the most suitable technique based on individual needs and goals.

Another phonosurgery is Wendler's glottoplasty that can be used for transgender vocal feminization. It aims to raise the pitch and create a more feminine voice. The procedure involves modifying the vocal folds, often by shortening or tightening them. The specific techniques may vary among surgeons. Prior evaluation and consultation with a qualified specialist are necessary, and voice therapy is often recommended for optimal results. Ultimately, this systematic review endeavors to contribute to a better understanding of the broader scope of voice feminization interventions and their impact on transgender individuals' overall voice satisfaction and gender affirmation.

METHOD

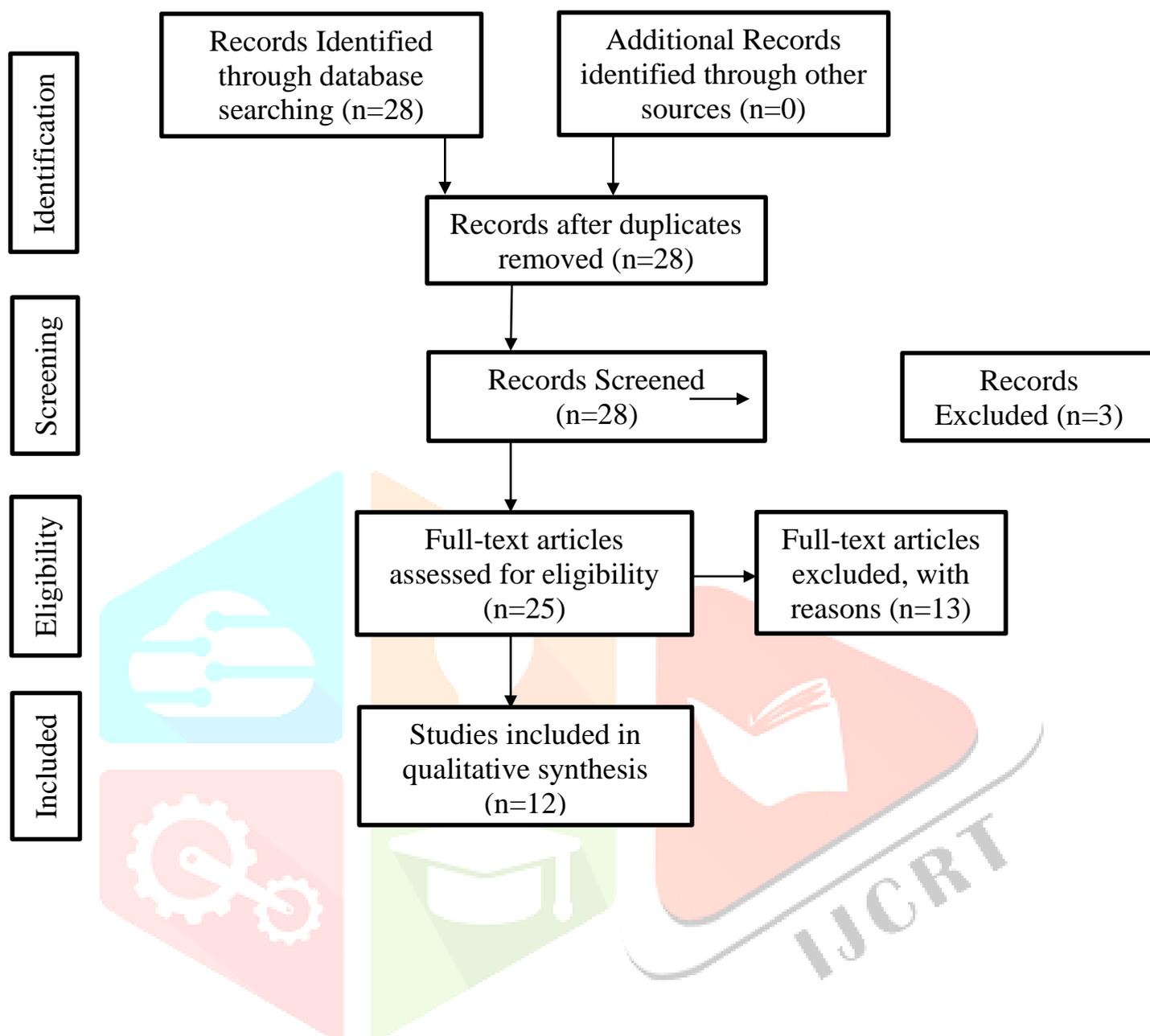
In this systematic review, a thorough and extensive search was conducted across multiple reputable databases, including Openventio, Sciencedirect, Sagepub, Elsevier, Dovepress, EBSCOhost, PubMed, ResearchGate, and Google Scholar. The search strategy utilized relevant terms associated with transgender phono surgery, voice feminization, vocal pitch, and voice therapy. The objective was to identify studies that investigated interventions specifically aimed at improving vocal pitch in transgender individuals. To ensure the inclusion of appropriate studies, specific criteria were applied. These criteria focused on research that centered on transgender individuals undergoing feminizing voice therapy or phono surgery with the explicit purpose of enhancing vocal pitch. The researchers prioritized the inclusion of the latest research articles. A rigorous assessment was then conducted to evaluate the quality and relevance of the selected studies to the research question.

Data extraction was performed to gather essential information from the included studies. This involved capturing key findings, methodologies utilized, sample sizes, details of the interventions employed, and outcome measures reported in each study.

Initially, 25 abstracts were identified and subjected to a meticulous eligibility assessment. The selection process involved independent data extraction, with a primary focus on the methods used for vocal pitch enhancement and the specific non-surgical and surgical techniques described in recent studies. Additionally, the researchers conducted a comprehensive review of the references cited in all identified abstracts to ensure that no relevant studies were overlooked.

Out of the 25 reviewed abstracts, a total of 12 studies met the pre-defined inclusion criteria and were included in the systematic review. Exclusion criteria encompassed the exclusion of data from genetically female individuals, studies involving participants who had previously undergone vocal feminization and hormonal therapy, studies employing more than one simultaneous surgical technique to increase pitch, studies lacking acoustic analysis or reported pre- and postoperative frequencies, studies with fewer than three descriptions of the same surgical technique, and studies with fewer than three subjects. By following this rigorous methodology, the researchers ensured a comprehensive and systematic analysis of the selected studies, providing valuable insights into the interventions for vocal pitch enhancement in transgender individuals.

Figure 1. Preferred Reporting Items for Systematic Reviews flow diagram:

**Result:**

Study selection: The initial search and reference review yielded 28 unique studies, of which 12 met inclusion criteria (Fig. 1). 6 studies provided the combined data for feminizing voice therapy and phonosurgery; 1 study is based upon voice therapy, and other 5 articles are based upon phonosurgery (Wendler's Glottoplasty, Endoscopy Shortening, Cricothyroid Approximation, and Laser Assisted Voice Adjustment).

Articles reported outcomes using various assessments (e.g., Voice Handicap Index, Hirano GBRAS scale, PROM, Transgender self-assessment questionnaire Transsexual Voice Questionnaire, measures of satisfaction by the participants, and measures of femininity by unfamiliar listeners), as well as the outcome measures identified in the inclusionary criteria.

1. Wendler's Glottoplasty:

Wendler's glottoplasty, particularly when modified by Hagen, has been found to be an effective and low-risk method for elevating vocal pitch without compromising voice quality. This endoscopic technique involves approximating the anterior one-third of the vocal cord, which leads to significant improvement in fundamental frequency (F_0), often around 200Hz. Importantly, these improvements remain stable during the follow-up period. (3,6)

The success of Wendler's technique relies on specific surgical steps. The procedure involves de-epithelialization of only the anterior third of the vocal folds, followed by suturing in a V shape. This results in shortening of the vocal folds and a reduction in their vibrating mass, leading to an increased emission tonal frequency. Notably, the narrowing of the endolaryngeal lumen does not seem to affect rest or effort breathing in our experience. . (7)

Temporary postoperative hoarseness may be observed for a few weeks following the procedure. However, this hoarseness can be effectively addressed through speech therapy. It is important to note that Wendler's technique offers long-term positive outcomes and avoids the need for anti-aesthetic cervical incisions required by other techniques. (7)

A systematic review showed that individuals who undergo Wendler's glottoplasty (WG) for voice feminization experience higher frequency gains compared to vocal training (VT). However, WG patients may have a more restricted frequency range post-surgery, while VT patients exhibit an increased range. These findings have varying implications for different transgender individuals, highlighting the need for personalized considerations when choosing between WG and VT for voice feminization. (2)

Studies have consistently reported favorable results with Wendler's glottoplasty, making it a safe and effective procedure for feminizing the voice of transgender women. The procedure leads to an increase in fundamental frequency without exacerbating other acoustic parameters or compromising voice quality. Overall, this technique provides a systemic approach to achieving desired voice feminization outcomes. (12)

2. Endoscopic Shortening Technique:

The endoscopic shortening technique demonstrated the largest increase in fundamental frequency, with a mean difference of 78.98 Hz (CI: 60.76-97.21) between pre- and postoperative measurements. (1,3,5)

The endoscopic shortening group exhibited high heterogeneity ($I^2 = 90\%$) due to variations in vocal pitch outcomes across different studies. The postoperative increase in pitch ranged from 43 to 110 Hz. (1,3,5)

The endoscopic shortening procedure involves shortening the vibrating length of the vocal folds by creating a new anterior commissure. It was first described by Wendler and offers the advantage of being a minimally invasive technique without requiring an external approach. However, the procedure is irreversible and carries the risk of postoperative hoarseness. Voice therapy following the procedure helps increase F0, stabilize the voice, and create a more feminine timbre. (3)

One Study on endoscopic shortening reported satisfactory ratings for voice-related quality of life in 82.5% of patients. Another study on Self-reported perception measures showed improved scores for voice quality, increasing from 40 before treatment to 70.3 following treatment. (11)

Patients undergoing endoscopic shortening experienced a shift on the masculinity-femininity scale, with their voices changing from "somewhat masculine" pre-treatment to "somewhat feminine" post-treatment. (5)

Complications associated with endoscopic shortening included reduced mean phonation time (61%), pitch instability (1.9%), decreased loudness (1.7 to 6%), dysphonia (1.7%), and approximation. (5)

Endoscopic shortening was most effective at pitch elevation, raising F0 by over 70 Hz, versus a change of 26 to 40 Hz achieved by voice therapy and the other surgical options. Endoscopic shortening also achieved the highest postoperative F0, resulting in pitch that fell well within the typical female range. (5)

3. Cricothyroid approximation (CTA):

Cricothyroid approximation (CTA) was introduced by Kitajima, Tanabe, and Isshiki as a method to address low pitch voice in women. Interrupted sutures were used to approximate the cricoid and thyroid cartilages, with small pieces of silicon placed underneath to prevent cartilage tearing. Each 1mm of approximation resulted in a pitch elevation of 0.15 to 0.90 semitones. (3,7,11)

Long-term outcomes of CTA have been questionable, as the pitch tends to drop over time, possibly due to suture loosening. One study included in a meta-analysis had 6 patients, none of whom achieved sufficient pitch elevation over time with the CTA approach. (1)

The CTA demonstrated the second highest (after Endoscopic shortening technique) increase in fundamental frequency, with a mean difference of 44.97 Hz (95% CI, 36.08-53.86), between pre- and postoperative measurements. (1)

A study by Elena Mora et al compared CTA and glottoplasty (GL) in 28 CTA and 23 GL cases. Both groups showed improvement in mean fundamental frequency (Fo), but the increase was 27 Hz higher after GL than after CTA. Fo decreased over time after CTA but remained stable after GL. (3,24)

CTA is considered a form of pitch-raising surgery but is not a true voice feminization procedure as it does not bring about morphological or physiological changes. It primarily causes a persistent cricothyroid muscle response. Additionally, CTA does not alter the acoustic tube dimensions that differ between males and females, and the tension after CTA is initially high but decreases over time. (4)

In one study on cricothyroid approximation, postoperative femininity ratings on a scale of 0 (very male) to 100 (very female) were reported as 42.38, which fell between ratings for non-transgender men (14.51) and non-transgender women (79.38). (5)

Complications associated with cricothyroid approximation were limited but included decreased loudness (6%), vocal fatigue (6%), and hoarseness (3%). (5)

The increase in Fo through cricothyroid approximation was reported to be 39.46 Hz (95% CI -62.89 to -16.02). (5)

Surgically, CTA involves increasing the tension of the vocal cords without interfering with the internal structures of the larynx, thereby minimizing the risk of voice irregularities. While early results have been described as good, long-term issues such as tension loss, cartilage necrosis, and larynx damage due to high tension have also been reported. (6)

4. Laser Reduction Glottoplasty (LRG):

Orloff described the Laser Reduction Glottoplasty (LRG) procedure, which involves vaporizing the vocal fold membrane using a CO2 laser to increase vocal cord stiffness and raise the fundamental frequency. On average, LRG results in a pitch increase of 26 Hz. However, there are cases where no change or a deeper voice is observed after laser-assisted voice adjustment. LRG has shown

improvements in voice femininity, congruity with self-image, and satisfaction, but it may also lead to decreased vocal quality, loudness, and vocal range. Postoperative voice therapy is beneficial for optimizing outcomes. (3, 6, 11)

The Laser Reduction technique is characterized by a relatively smaller increase in fundamental frequency, with a mean difference of 36.89 Hz (95% CI, 20.06-53.72), between pre- and postoperative measurements. The heterogeneity in the laser reduction group is low ($I^2 = 24\%$). (1)

In terms of satisfaction, one study reported no net change, while another reported 66.7% complete satisfaction and 33.3% partial satisfaction following laser reduction glottoplasty. (5)

A study on laser reduction glottoplasty reported an increase in female perception and a decrease in male perception following treatment. Specifically, the perception of femininity improved from 1.5 to 8.5 on a 10-point scale, while the perception of masculinity decreased from 6.7 to 1.0. (5)

Complications associated with laser reduction glottoplasty are limited but may include the formation of granulation tissue (3.2%). Similar complications reported for cricothyroid approximation include decreased loudness (6%), vocal fatigue (6%), and hoarseness (3%). (5)

The laser reduction procedure resulted in an increase of 26.00 Hz (95% CI -50.39 to -1.61). However, the laser reduction group included only one study, so heterogeneity could not be assessed. (5)

A study by Koçak et al demonstrated good long-term results in eight male-to-female patients who underwent laser reduction glottoplasty when CTA was failed to show result. (6,25)

B. VOICE THERAPY:

Voice therapy, a non-invasive and cost-effective treatment option, aims to modify the voice of individuals, particularly male-to-female transgender individuals, to align with their identified gender. The treatment goals of voice therapy include increasing fundamental frequency, adopting more feminine intonation, and achieving forward resonance. This is typically achieved through vocal exercises that target pitch and the use of audio recordings for self-monitoring of intonation. (2,3)

Voice therapy offers several advantages over surgery, such as its noninterventional nature and its ability to address parameters beyond fundamental frequency (F0). It has been found to be effective in raising the pitch of the speaking voice, improving patient satisfaction, and increasing externally-rated vocal femininity. Unlike surgical procedures, voice therapy also addresses non-pitch-related aspects of vocal femininity.

(4,5)

Both preoperative and postoperative voice therapy play important roles in raising pitch compared to surgery alone. Voice therapy alone has been shown to increase F0 by an average of 30.90 Hz, with post-intervention mean differences ranging between 13.9 to 42.6 Hz. Patients who undergo postoperative voice therapy achieve significantly greater increases in F0, stabilization of the voice, reduced vocal irregularities, and a more feminine timbre compared to those who do not receive postoperative therapy. (3,5)

Patient satisfaction with voice therapy has been reported to be high, with studies showing a 65% increase in self-rated femininity and a patient satisfaction score of 80 out of 100. However, voice therapy does come with its own financial burden and requires a significant time investment, which may be impractical for some individuals. (5)

It is worth noting that there can be a discrepancy between objective voice parameters and subjective voice perception or satisfaction, particularly in male-to-female transgender individuals. (6)

Voice therapy provides a non-invasive method that not only helps individuals adjust their voice but also their behavior to identify with their gender. This comprehensive approach distinguishes voice therapy from solely focusing on pitch elevation. (7)

Patients who underwent postoperative voice therapy after surgical procedures achieved a significantly higher increase in fundamental frequency (F0) compared to those who did not receive postoperative therapy (50.60 Hz versus 22.77 Hz, $P < 0.0001$). (5,6)

The content of voice therapy should be individualized as not all voice techniques work universally. Treatment goals should be tailored to each person's specific needs. A period of only 10 therapy sessions may not be sufficient to fully generalize speech feminization techniques in daily life. (9)

In summary, voice therapy offers a non-invasive and comprehensive approach to modify the voice, particularly for male-to-female transgender individuals. It addresses various aspects of vocal femininity, including pitch, and has been shown to increase patient satisfaction. However, it requires a significant investment of time and finances. The individualized nature of voice therapy ensures that treatment goals are tailored to each person's unique needs.

- ✓ Based on the available data, post operative patient satisfaction rates for different interventions were as follows: voice therapy, Wendler's glottoplasty, and endoscopic shortening all showed satisfaction rates of approximately 80% to 85%. However, it's important to note that Wendler's glottoplasty was associated with the highest increase in fundamental frequency (F0), followed by endoscopic shortening, voice therapy, cricothyroid approximation, and laser reduction glottoplasty. Additionally, complications were reported more frequently with cricothyroid approximation and laser reduction glottoplasty compared to interventions focused on increasing F0.

CONCLUSION –

The literature indicates that both voice therapy and phonosurgery are viable options for individuals seeking to modify their vocal pitch, but the choice depends on factors such as the desired magnitude of pitch change, cost considerations, and tolerance for potential complications. In general, most individuals are likely to benefit from voice therapy due to its high satisfaction rates, ability to raise vocal pitch, and non-invasive nature. Voice therapy offers a comprehensive approach to voice modification.

However, there are surgical options available as well. Wendler's glottoplasty modified by Hagen and endoscopic shortening have been found to be effective in enhancing vocal pitch while preserving voice quality. These surgical interventions provide alternatives for individuals seeking more significant changes in pitch.

If an individual decides to undergo surgery, postoperative voice therapy can further enhance outcomes. It can increase fundamental frequency (F0), stabilize the voice, and improve vocal pitch. Combining surgery with voice therapy may yield optimal results.

It is important to note that further research is needed to establish definitive clinical recommendations in this field. Factors such as individual preferences, goals, and medical considerations should be carefully evaluated to determine the most suitable treatment approach for each patient.

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