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A Systematic Review Evaluating the Effectiveness of Vagal Methods for Conversion to a Sinus Rhythm in Stable Supraventrical Tachycardia

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A Major Paper Presented

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Abstract

The preferred first line treatment for adults in stable supraventricular tachycardia (SVT) presenting to an emergency department varies between practitioners. Some practitioners will choose a non-pharmacological intervention as a first line treatment while others will choose a pharmacological intervention. This study analyzes the efficacy of vagal maneuvers in the termination of SVT to sinus rhythm, more specifically comparing Standard Vagal Maneuvers (SVM) to Modified Vagal Maneuvers (MVM). This study was conducted through a systematic review of the literature. The main goal was to increase the use of non-pharmacological interventions as a first line treatment and to raise awareness of the importance efficacy of the intervention to convert SVT to a normal sinus rhythm.

The Stetler Model of Evidence-Based Practice guided this systematic review, serving as an example of how research findings are applicable to daily practice, by using evidence to implement change (Stetler, 2001). This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Using PRISMA, current literature was searched to select randomized control trials in the databases Cumulative Index of Nursing and Allied Health Literature (CINAHL) and PubMed, with the search words "SVT" or "supraventricular tachycardia" or "paroxysmal supraventricular tachycardia", "vagal maneuvers" or "vagal methods", and "non-pharmacological treatment". Data from the studies were then appraised using Critical Appraisal Skills Programme (CASP) checklist, then tables were created to organize data clearly, and finally, a cross study analysis table was developed.

Three randomized-control trials met the inclusion and exclusion criteria. The findings of the cross-study analysis determined that the modified vagal maneuver is more successful in the conversion of SVT to a sinus rhythm than the standard vagal maneuver.

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I would like to express a special thanks and gratitude to my professor and first reader Kara Misto, PhD, RN, for teaching and guiding me throughout this major paper journey. A tremendous thank you to my mother who has provided me with unwavering support and encouragement during completion of this paper, I couldn’t have done it without you. Finally, thank you to my husband and children who have motivated me to keep going, I love you all.

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A Systematic Review Comparing the Effectiveness of Standard Vagal Maneuvers to Modified Vagal Maneuvers for Conversion to a Sinus Rhythm in Stable Supraventricular Tachycardia

Background/Statement of the Problem

A normal adult heart rate is between 60 to 100 beats per minute (Morton & Fontaine, 2018). One variation of this typical heart rate is stable supraventricular tachycardia (SVT), which is defined as a regular, monomorphic, rapid atrial rhythm with a rate of 150 to 250 beats per minute. SVT is also referred to as paroxysmal supraventricular tachycardia (PSVT), meaning that it comes and goes, usually by abruptly starting and stopping (Morton & Fontaine, 2018). To correctly diagnose stable SVT the medical care provider needs to interpret an electrocardiogram (ECG) which displays the electrical conduction of the heart (Sohinki & Obel, 2014).

SVT often occurs in a normal healthy heart and may be triggered by stimulants such as caffeine, tobacco, cocaine, physical activity, or emotional stress. If preexisting heart disease is present it may act as a background for SVT (Morton & Fontaine, 2018). A patient in SVT may be asymptomatic or experience anxiety, palpitations, or some light-headedness (Morton & Fontaine, 2018). SVT is commonly identified in emergency departments (ED), with an incidence of 35 cases per 100,000 patients (Sohinki & Obel, 2014). In the United States alone there are approximately 89,000 new cases of paroxysmal supraventricular tachycardia per year (Page et al., 2015).

In the acute management of stable SVT, vagal maneuvers are the appropriate first treatment option (Sohinki & Obel, 2014). An increased intrathoracic pressure stimulates baroreceptors during the vagal maneuver, causing increased vagal input on the AV node, resulting in a slowing of the heart rate. This can be accomplished a few different ways; one, through a standard Valsalva maneuver in a supine or semi recumbent position, second by a modified Valsalva maneuver that employs the Trendelenburg position, and a third method using a carotid sinus massage. The Valsalva maneuvers are more commonly chosen in practice, in comparison to carotid massage, due to the caution needed when performing a carotid sinus massage in the elderly. A carotid massage may increase the risk of a carotid aeroembolism and stroke (Sohinki & Obel, 2014).

Historically, the management of SVT varies greatly from no intervention to the use of vagal maneuvers or pharmacological therapies (Smith, Dyson, et al., 2015). This may be due to a gap in a collection of evidence about the use of vagal maneuvers for the treatment of SVT. Vagal methods aren't found to have any adverse events (Appelboam et al., 2015), while pharmacologic interventions may have adverse events such as hypotension or palpitations that can cause discomfort for the patient and may require treatment for correction (Dogan et al., 2015). Therefore, the use of vagal methods as a first line treatment may prevent the patient from receiving unnecessary medication that may cause harm or discomfort. This systematic review compared the effectiveness of standard vagal to modified vagal methods in adults for conversion of stable SVT to a sinus rhythm.

Literature Review

A literature review was conducted using an electronic search of the databases Cumulative Index to Nursing and Allied Health Literature (CINAHL), Google Scholar, Cochrane Library and PubMed. Literature was searched using the keywords vagal maneuvers, supraventricular tachycardia, adenosine, and non-pharmacological treatment, searched both individually and combined. The literature review was limited to the English language, peer reviewed journals, years 2010- 2020, and healthcare provided in the ED involving adults. Exclusions consisted of any pediatric studies or studies with participants less than the age of 18, not a randomized control trial, studies that do not include a diagnosis of stable SVT with the use of a pharmacological or non-pharmacological intervention, studies not written in the English language and studies published before the year 2010.

Background

Morton and Fontaine (2018) state that cardiac muscle (myocardial) has cells that need to receive an action potential simultaneously in order to conduct and create a heartbeat. This action potential is accomplished through a pathway system in the heart with cells that have automaticity. When the action potential causes a depolarization the calcium and sodium ions move from the outside of the cell to the inside and the potassium ions move from the inside to the outside, this creates a cell membrane with more negatively charged particles on the outer surface than the inner (Morton & Fontaine, 2018). The sinoatrial node (SA node) acts as the heart’s pacemaker, having the fastest automaticity discharge at 60 to 100 beats per minute. The next node to conduct a heartbeat if the SA node fails is the atrioventricular node (AV node), which will conduct a beat at 40 to 60 beats per minute. Close by is the bundle of His, that connects to the Purkinje fibers which are the heart's last effort at conducting a beat at a rate of 20 to 40 beats per minute (Morton & Fontaine, 2018).

An electrocardiogram (ECG) shows the electrical conduction of the action potential through the heart. The depolarization of the SA node in top chambers of the heart will appear as a p-wave. If conduction is uninterrupted there will then be depolarization of the bottom chamber of the heart, appearing as a QRS that is narrow, meaning that the heartbeat originated from the top chamber (Morton & Fontaine, 2018). This normal heart beat and electrical conduction is important for the medical care provider to recognize and interpret ECG rhythms. Supraventricular tachycardia occurs at a rate of 150 to 250 beats per minute and is considered a rapid atrial rhythm. Supraventricular tachycardia is also referred to as paroxysmal supraventricular tachycardia (PSVT), meaning that it comes and goes, usually by abruptly starting and stopping. To correctly identify SVT, the ECG should show a normal appearing QRS, meaning that it is narrow and monomorphic, with a regular rate (Morton & Fontaine, 2018).

SVTs are a common cause of patients presenting to a hospital and acute admission and may cause a significant amount of discomfort and distress in the patient (Kotadia et al., 2020). SVT has been found to have a female predominance of 2:1 across all age groups. SVT increases patient morbidity, especially when symptoms are frequent or incessant, it can be life-threatening in a small group if found to have pre-excitation with atrial-fibrillation or ventricular rhythms (Kotadia et al., 2020).

The American Heart Association published guidelines for management in adult patients with SVT in which they state that patients with SVT may experience recurring symptoms that negatively impact their quality of life. While a patient is experiencing episodes of tachycardia, they can feel lightheaded and may have syncope, which can become an obstacle to the performance of usual activities of daily living such as driving. However, there are minimal data on the effect of treatment on the quality of life for patients with SVT (Page et al., 2015).

SVT Management

There are two broad categories in the management of SVT, either nonpharmacological or pharmacological interventions examined in this literature review. Stable SVT often terminates through the use of Valsalva maneuver or carotid massage, if these fail then Adenosine may be administered. If pharmacological treatment is also unsuccessful then cardioversion or overdrive demand pacing is an option. A cardiac ablation or long-term prophylactic therapy may be required (Morton & Fontaine, 2018). The research varies, however, there is a common theme of two or three vagal maneuver attempts for an adult patient in stable SVT before advancing to a pharmacological treatment. Smith, Dyson, et el., (2015) report that in 1704 Antonio Valsalva coined the term Valsalva Maneuver. In the publication of his seminal work *De Aura Humana Tractatus,* the term was used to describe a means of expelling pus from the middle ear of a patient.

Pharmacological Treatments

Pharmacological treatment of stable SVT should be initiated after at least two attempts at vagal maneuvers have failed (Morton & Fontaine, 2018). Adenosine is an antiarrhythmic medication, that slows conduction through the AV node. It is given intravenously by a rapid-push due to a 10-second half-life of the drug. The first dose is given at a dose of 6 milligrams (mg), and if unsuccessful, an additional two doses of 12mg can be given. If Adenosine fails, another medication like a calcium channel blocker or a beta blocker will be considered prior to the use of electrical therapy (Morton & Fontaine, 2018).

Sohinki and Obel (2014) state that Adenosine will cause a temporary complete AV node block, with a transient sinus arrest or bradycardia. This means that the patient's electrical conduction and heart beat will pause for a short period of time before the medication "resets" the hearts electrical conduction pathway system and in turn converting the SVT back to a normal sinus rhythm. Side effects of Adenosine may be chest discomfort, dyspnea, or a patient may experience short-lived sensations of claustrophobia (Sohinki & Obel., 2014).

Calcium channel blockers are an antiarrhythmic medication, that slow the heart rate down by decreasing automaticity in the SA and AV nodes, slow conduction, and prolong the AV node refractory period (Morton & Fontaine, 2018). One such calcium channel blocker is verapamil, which may be given intravenously as an infusion of 5mg over 2 minutes with a repeated dose of 7.5mg over 5-10 minutes if unsuccessful. Yet another commonly used calcium channel blocker is diltiazem, which can also be given intravenously, with 20 mg administered rapidly for a first dose. If necessary, diltiazem can then be administered a second time in a dose of 25-35mg. Common adverse events that results after the administration of calcium channels blockers include hypotension, peripheral edema, nausea, AV block, bradycardia, flushing, and constipation (Morton & Fontaine, 2018).

Smith, Taylor, et al. (2015), conducted a retrospective case study that measured the effectiveness of a revised clinical practice guideline (CPG) for the pre-hospital management of supraventricular tachycardia by paramedics. At the time the paramedics were using vagal maneuvers and electrotherapy in the old CPG, the revised CPG expands their scope of practice to include administration of Adenosine and verapamil. The study included 823 adults, who were predominantly female, aged approximately 57 years old and mostly from the Victorian metropolitan area of Australia. Adenosine was found to have a higher conversion rate at 89.1%, than verapamil at 70.6% (Smith, Taylor, et al., 2015). Limitations were found with the choice of medication by the paramedic being adenosine 30.7% of the time and verapamil 4.2%, which prevented further comparative analysis being performed. An adverse event of hypotension after administration of verapamil was found in 41.2% of patients. No adverse events were reported after adenosine administration. Overall, Adenosine was found to have a higher conversion rate to normal sinus rhythm than verapamil (Smith, Taylor, et al., 2015).

Dogan et al. (2015) performed a retrospective chart review study on adult patients presenting to the ED, to investigate the use of ECG criteria in discerning between atrioventricular nodal reentry tachycardia (AVNRT) and atrioventricular reentrant tachycardia (AVRT). The identification of either AVNRT or AVRT was then used to determine a treatment of either adenosine or diltiazem (Dogan et al., 2015). The study population included 77 patients (36 male and 41 female), the ECG criteria included a visible P-wave, aVL notch, Pseudo S-wave and Pseudo R-wave. Electrocardiogram criteria has been used to determine a need for ablation treatment in SVT patients but has not been used for the emergent treatment of stable SVT patients. The results showed 59.6% of patients converted after the first dose of adenosine, and increased to 64.91 % with the second dose and further increased to 71.92% after third dose. Adenosine doses were administered as 6mg, 12mg, and 12mg, respectively. Patients who received diltiazem converted 95% of the time after the first dose. The rate increased to 96.9% when diltiazem was administered to patients who were unresponsive to adenosine. The study found no statistical significance between the administration of adenosine or diltiazem, in the treatment of acute episodes of AVNRT. The study found an adverse event of hypotension that required intervention and no mortality (Dogan et al., 2015). Overall, it was recommended that diltiazem be the first medication, compared to adenosine, in the presence of retrograde P wave and aVL notch in the ECG of the patients with stable SVT. (Dogan et al. 2015).

Likewise, Althunayyan et al., (2018) conducted a quantitative, retrospective study that aimed to compare the medical history, demographics, clinical presentation, and treatment of adult patients presenting to the emergency department in SVT. A secondary purpose was to see if variables such as presenting heart rate or medical history, could be identified as a predictor of adenosine response (Althunayyan et al., 2018). The research question asked if providers were able to predict the response of adenosine in PSVT based on initial presentation and history. Patients were divided into two groups: an adenosine sensitive group (AS-group) and an adenosine resistant group (AR-group). The AS-group consisted of patients who converted to sinus rhythm after the first 6 mg or second 12 mg dose of adenosine. The AR-group consisted of patients who did not convert after the first or second dose of adenosine. The study used a convenience sample of 38 patients (19 males and 19 females), with independent variables consisting of past medical history, demographics, and clinical presentation of PSVT (Althunayyan et al., 2018).

Althunayyan et al. (2018) found that vagal maneuvers were only attempted in 23% of patients with a conversion rate of 8.6% in those patients. Of the remaining 38 patients, 35% converted after the first dose of adenosine and 52% after the second dose. There was a total of 8 patients (21%) in whom adenosine was completely unsuccessful in conversion and either spontaneously reverted to a sinus rhythm or required further treatment. There were no significant findings regarding the difference between the AS-group and the AR-group, in age, demographics, past medical history, current medication, symptom presentation or duration. The majority of patients were found to be middle aged, with a previous episode of PSVT, and no history of heart disease. The ROC analysis was able to predict the optimal efficacy of adenosine through sensitivity and specificity. There was one notable clinically significant result. Investigators found that if the patient's heart rate was less than 176 beats per minute, and there was already one unsuccessful conversion after a first dose of adenosine, there was no need to use a second or third dose. It was determined that at this time a recommendation should be made for the use of another antiarrhythmic or rate control medication (Althunayyan et al., 2018).

Kotaldia et al. published an overview of diagnosis and management of SVT, in the Journal of Clinical Medicine in 2020. The authors recommend confirmation of SVT by 12-lead ECG, then assessment of the hemodynamic stability of the patient. If found to be stable, the acute management is to perform vagal maneuvers, if unsuccessful, an adenosine challenge can be administered via IV with a continuous ECG. If the Adenosine challenge is unsuccessful the provider may then choose between an IV calcium channel blocker such as verapamil or diltiazem, or a beta-blocker such as metoprolol. Beta-blockers are particularly useful in slowing the AV node conduction acutely, but are less efficacious in terminating the arrythmia (Kotaldia et al., 2020). If these pharmacological interventions are unsuccessful then a synchronized cardioversion is warranted (Kotaldia et al., 2020).

Risks or Benefits of Pharmacological Interventions

Even though pharmacological treatment options for supraventricular tachycardia have high conversion rates, it come at a price to the patient; not only a monetary cost but a physiological and psychological one as well, which providers need to consider before administration. Ahmad et al. (2021) conducted a systematic review of the treatment for PSVT and the purpose was to compare the safety and efficacy of calcium channel blockers and adenosine. The authors found that with adenosine many patients encounter short-lived but exceptionally unpleasant side effects after administration, such as sense of impending doom, dyspnea, and flushing, all that may be incredibly frightening. Adenosine though more expensive than other intravenous medications is still the drug of choice, and found to be the most successful at termination of PSVT (Ahmad et al., 2021). The authors found that calcium channel blockers may cause negative inotropy and peripheral vasodilation resulting in hypotension, particularly when patients have impaired left ventricular function (Ahmad et al., 2021).

Non-pharmacological or Alternative Treatments

Though the use of pharmacological methods to treat SVT have for many years been used very commonly, as noted there can be serious unwanted and detrimental side effects. Thus, it has been demonstrated for centuries, that stable SVT often terminates through the use of non-pharmacologic methods such as Valsalva maneuver or carotid massage (Sohinki & Obel, 2014). The standard vagal maneuver (SVM) is performed in the semi-recumbent position (45-degree angle) for 15 seconds and the patient remains in that position at least one minute afterwards. The modified vagal maneuver (MVM) is started in the same semi-recumbent position but then immediately after the 15 second strain, the patients head is lowered to a flat position and the legs passively raised to a 45-degree angle for 15 seconds, then the legs lowered flat the head raised back to a semi-recumbent position for 45 seconds, before reanalyzing the heart rhythm. Most evidence related to use of these methods recommends two or three vagal maneuver attempts for an adult patient in stable SVT before advancing to a pharmacological treatment (Sohinki & Obel, 2014).

A systematic review titled *Effectiveness of the Valsalva Manoeuvre for Reversion of Supraventricular Tachycardia* (Smith, Dyson, et al., 2015) reviewed randomized control trials. Inclusion criteria consisted of participants having a sinus rhythm at baseline, no known cardiac disease, and found to be in stable SVT. The interventions compared were the SVM to the MVM. Studies were excluded if the SVM was compared to a different vagal maneuver such as the carotid massage or dive reflex. The primary outcome analyzed was the conversion of SVT to a sinus rhythm.

The authors found that three things were required to produce the maximum effect of a vagal maneuver; the patient should be supine, a pressure of 40mmHg must be generated in the intrathoracic cavity, and the individual must hold the strain for a minimum of 15 seconds. Pre-existing comorbidities such as diabetes and respiratory or cardiovascular disease may lower the odds of having a successful vagal maneuver (Smith, Dyson, et al., 2015). Creating a minimum amount of 40mmHg is not easily obtained by the patient and requires thorough and repeated education by the provider including demonstration and return demonstration.

Smith, Dyson, et al. (2015) stated that the avoidance of possible aggressive therapies is a fundamental component of performing vagal maneuvers as a first line treatment with patients in stable SVT. Additionally, Smith, Dyson, et al. (2015) report that one third of the patients who called 911 spontaneously converted back into a sinus rhythm prior to the paramedics' arrival; therefore, not requiring any medical intervention and the need for invasive or expensive medical care is avoided.

Results from the study utilized descriptive statistics only, with no meta-analysis, specifically related-to the high level of methodological and clinical heterogeneity (Smith, Dyson, et al., 2015). Thus, causing the authors to have insufficient evidence to support or refute the effectiveness of the Valsalva maneuver for termination of supraventricular tachycardia. The authors believe that obtaining a large sample size in future studies is possible, due to the high prevalence of SVT. In future research, an emphasis needs to be placed on the effectiveness of vagal maneuvers due to age and pre-existing medical conditions (Smith et al., 2015). Based on their clinical research findings, recommendations suggested that future research be conducted using a standardized approach in performing the vagal maneuver technique and methodology of research (Smith et al., 2015).

A quasi-experimental study, titled *Valsalva maneuver Using a Handmade Device in Supraventricular Tachycardia Reversion* (Motamedi et al., 2017), assessed the success of Vagus nerve stimulation via a handmade device to the conversion of sinus rhythm, for adult patients presenting to the emergency department in stable SVT. The study included 100 patients with a mean age of 53, 67% were female and 33% male. The maneuver was performed using the handheld device in the supine position, with 30 to 50 mmHg pressure for 15 seconds (Motamedi et al., 2017).

Motamedi, et al. (2017) found that 12% of the patients were unable to properly perform a vagal maneuver. Out of the remaining patients 85.2% were unsuccessful in the conversion of SVT to sinus rhythm. Overall, 14.8% of patients succeeded in reversion, of those 6 patients were successful on the first attempt and 7 on the second attempt. Of interest, the only independent related factor of successful reversion found by the authors was the patient having had a history of SVT, which requires further evaluation (Motamedi et al., 2017).

Risks or Benefits of Vagal Methods

Appleboam et al., 2015 did not identify any disadvantages of using the modified Valsalva maneuver technique, however, a cost-free, simple, and well tolerated postural modification of the SVM was found to be highly effective. As long as individuals can safely undertake a Valsalva strain and be repositioned as described, this maneuver can be used as the routine initial treatment for episodes of supraventricular tachycardia regardless of location. The technique could prevent many patients from being treated with drugs or even seeking health care. Clinicians who encounter this condition should consider learning the technique and teaching it to patients after a first episode of supraventricular tachycardia (Appelboam et al., 2015).

In summary, there are no published studies found that compared vagal methods to pharmacological interventions for the treatment of stable SVT. The research studies found either compared standard vagal to modified vagal methods or pharmacological to other pharmacological treatments. Of interest, these studies reported that vagal methods weren't found to have any adverse events while pharmacologic interventions had adverse events such as hypotension or palpitations that can cause discomfort for the patient and may require treatment for correction.

Theoretical Framework

The Stetler Model of Evidence-Based Practice guided this systematic review. The Stetler theory served as an example of how research findings are applicable to daily practice, by using evidence to implement change (Stetler, 2001). The two main concepts of the Stetler theory include research and evidence-informed practice, with a goal of enhancing overall application of research into daily practice (Stetler, 2001). The Stetler model consists of five phases; preparation, validation, comparative evaluation/decision making, translation/application and evaluation (Stetler, 2001, p. 276). The purpose of these phases is to encourage critical thinking about use of research, application of the evidence into daily practice, and help alleviate some human errors made during the decision-making process (Stetler, 2001).

The Stetler theory utilizes the application of five phases; in phase one it identifies the purpose of the study, contextual factors and consider sources of research gathered. Phase two assesses the reliability and trustworthiness of the research along with summarizing relevant findings. Phase three determines the applicability of summarized findings. Phase four helps to assess practice implications and plan a formal dissemination. Lastly, phase five evaluates the findings for application into practice by using formative and outcome data evaluation (Stetler, 2001).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines are used as framework for a systematic review. As clinical research progressed over time, the simplicity of the framework created an increased popularity of meta-analyses and systematic review usage. In turn, increasing and the need for a review and modernized framework. The modernized, reconstructed framework was titled

"*PRISMA*", structured by an interdisciplinary team for a holistic, multidisciplinary viewpoint.

PRISMA is intended to improve the ease of understanding and organizing previous research of systematic reviews, specifically in evaluating an intervention. Quality assessment and review is accomplished through a twenty-seven-item checklist, including sections from each major section, i.e., title, introduction, methods, results, discussion, and funding. Additionally, each section is strictly defined with subheadings that help readers and researchers alike to gain an understanding of what is expected in terms of quality and completeness of research. The first phase is 'identification of records' through utilization of academic databases, followed by article screening, eligibility, and lastly reviewing the number of studies included in the synthesis, also known as "inclusion". An area of concern is the potential for reader-bias and understanding that systematic reviews are at-risk for preconceptions and prejudice; this is considered a hallmark for thoroughness of conduct (Moher et al., 2009).

Method

Design

Systematic reviews differ from traditional literature reviews in that they use a more rigorous, well-defined approach to reviewing a specific subject area. Systematic reviews are designed to address well-focused questions about clinical practice. Systematic reviews are research reviews that combine the evidence of multiple studies related to a specific clinical problem to inform clinical practice (Whittemore & Knafl, 2005). The PRISMA framework for systematic reviews is highly recommended as a guide. This systematic review targeted a practice area where a limited number of experimental studies have been conducted.

Purpose of Study/Clinical Question

The purpose of this systematic review is to analyze research comparing standard vagal methods to modified vagal methods for adults with SVT. Using the Problem, Intervention, Comparison, and Outcome (PICO) format, the clinical question was: Among adult patients in the Emergency Department (P), what is the effectiveness of standard vagal methods (I) versus modified vagal methods (C), in the conversion of stable supraventricular tachycardia (SVT) to a sinus rhythm (O)?

Outcomes Examined

The specific outcomes assessed included the effectiveness of interventions such as standard vagal maneuvers and modified vagal maneuvers, as evidenced by the successful conversion to normal sinus rhythm, along with side effects/adverse events found.

Inclusion/Exclusion Criteria

The inclusion criteria for this systematic review included randomized controlled trials with human adult subjects, over the age of 18, diagnosed with stable SVT and given a vagal maneuver intervention in the ED, written in the English language, and studies conducted within the years 2010 – 2020.

The exclusion criteria consisted of any pediatric studies or studies with participants less than the age of 18, not a randomized control trial, studies that did not include a diagnosis of stable SVT with the use of a vagal maneuver intervention, studies not written in the English language and studies published before the year 2010.

Search Strategy

Research articles were obtained using an extensive electronic search of the databases Cumulative Index to Nursing and Allied Health Literature (CINAHL) and PubMed. Research was searched using the keywords SVT or supraventricular tachycardia or paroxysmal supraventricular tachycardia, vagal maneuvers or vagal methods, and non-pharmacological treatment, searched both individually and combined. The PRISMA flowchart and checklist was applied to the research, to aid in the inclusion criteria and selection into the systematic review. Duplicate research was removed, with the remaining articles assessed by the student researcher in an unblinded manner for inclusion criteria. This was be accomplished by first reading the title and abstract. Then if the research was found to be appropriate, the article was fully examined and critically appraised by the student researcher.

Data Collection for Each Study

The data collected from each study was entered into an excel table to review and present the articles included in the systematic review. The table summarized the data by organizing and displaying method/level of evidence, sample/setting, intervention, data analysis, results, and limitations (Moher et al., 2009).

Critical Appraisal

The Critical Appraisal Skills Programme (CASP) (2017) checklist for systematic reviews, was used by the student researcher to critically appraise each article and determine the credibility of the research (Critical Appraisal Skills Programme, 2017). The checklist determines the scientific purity and strength of the evidence through showing the relevance of outcomes found in the research. The CASP systematic review checklist consists of three parts, “Are the results of the trial valid?”, “What are the results?”, “Will the results help locally?” (Critical Appraisal Skills Programme, 2017). Each part was then broken down into multiple questions that aid in further clarification which are answered as “*yes*, *can’t tell*, or *no* “(Critical Appraisal Skills Programme, 2017).

Descriptive Data Synthesis

The data was then entered into data collection tables. A final table includes synthesized data for the cross-study analysis. This table consists of comparing each of the study’s applicable findings against all other research used in the systematic review. The findings were reviewed in the research section of this systematic review.

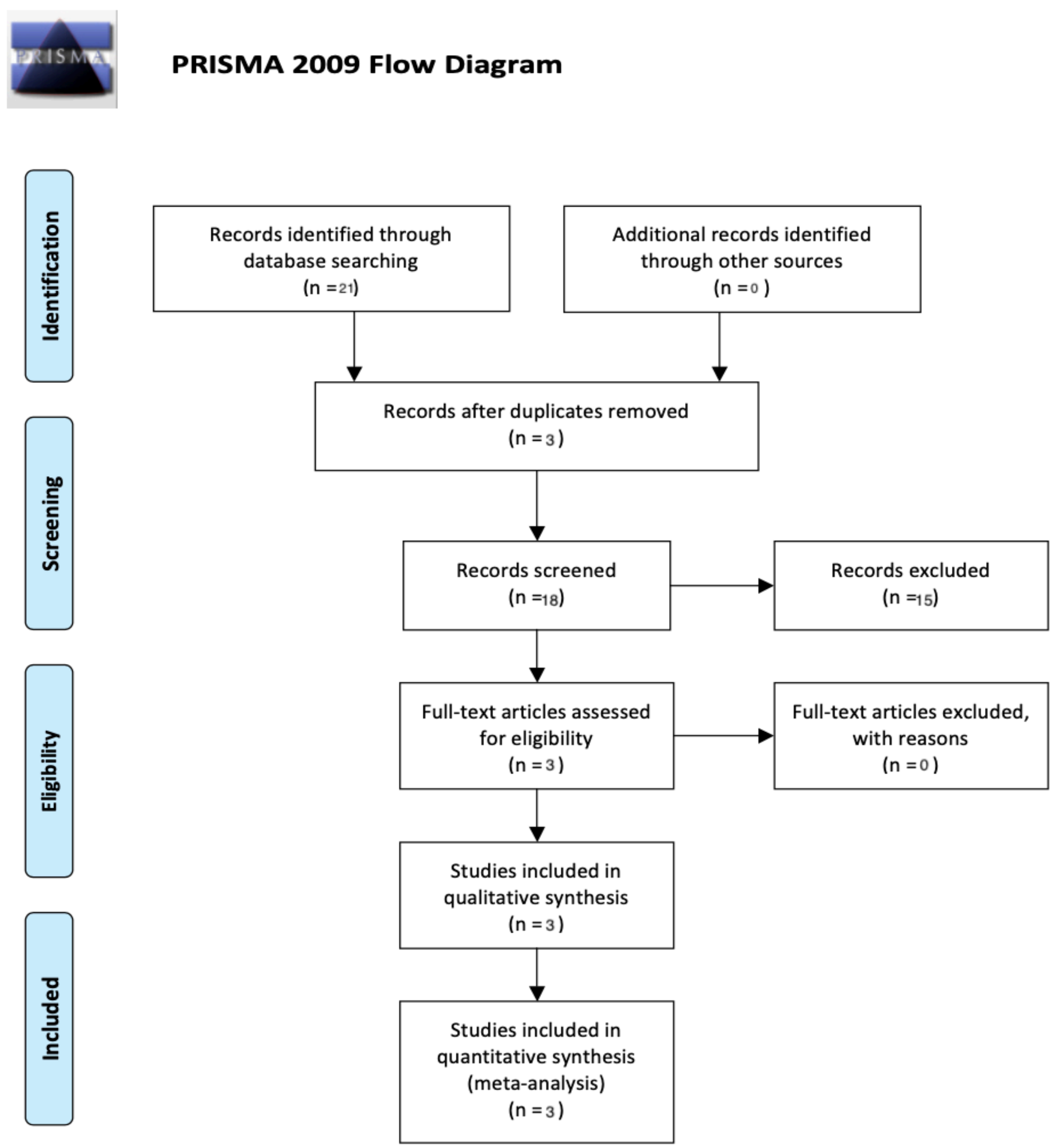
Cross Study Analysis

The findings from this study were analyzed to determine the benefits and risks of each recommended treatment option. This will include the rate of successful conversion to a sinus rhythm for each intervention and compare the benefits and risks of choosing a standard vagal maneuver to modified vagal maneuvers, including patient preference.

Results

Figure 1

Completed PRISMA flow diagram demonstrating article identification, screening, eligibility, and inclusion (Moher et al., 2009).



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

For more information, visit www.prisma-statement.org.

The completed PRISMA flow diagram as depicted in Figure 1 illustrates a visual analysis of how the three final studies were gathered to complete this systematic review. An initial search of the selected databases, CINAHL and PubMed, was completed using the search term "SVT or supraventricular tachycardia or paroxysmal supraventricular tachycardia", resulting in 6,472 studies. The addition of search term "vagal maneuver or vagal methods" narrowed the results to 68 studies. By adding "non-pharmacological treatment" to the search field, the results were narrowed down to 21 studies. A total of three articles were excluded due to duplication. After article screening, 15 studies were excluded due to failing to meet previously identified inclusion criteria. Lastly, the remaining three studies were appraised and chosen to complete this systematic review.

Each of the three studies selected and appraised for this systematic review include a description of the results with applicable study findings identified. Appendix A (Tables A1 – A3) depicts study specific data that was collected for each individual study. Each individual table includes the following key information: purpose of the study, study design, location, sample size, methods used, and vagal procedure performed. Following is Appendix B (Tables B1 – B3) which lists the outcome data that was collected. Study specific findings include: conversion rates of standard vagal maneuver and modified vagal maneuver. Each table does have a degree of individualization due to the variables in each study. Next, Appendix C (Tables C1 – C3) lists the critical appraisal data tables of individual studies that were created to assess the legitimacy, consistency, and applicability through a three-part, 11 question series. Finally, Appendix D, a cross-study analysis data table was created to assist in comparing the results of each individual study.

Individual Studies

Appelboam et al. (2015) (Appendix A – 1) conducted a randomized control trial (RCT), with a purpose of investigating the effect of a postural modification technique to the standard Valsalva Maneuver (SVM). The clinical question asked was, if a postural modification to the Valsalva maneuver could improve its effectiveness (Appelboam et al., 2015). The RCT was conducted in 10 emergency departments in England between 2013 and 2014. Inclusion criteria were adult patients presenting in SVT. Exclusion criteria consisted of patients unstable with hypotension (systolic BP below 90 mmHg), immediate cardioversion needed, atrial fibrillation or flutter, third trimester of pregnancy, inability to tolerate or perform maneuver, previous participation in the study. A total of 428 patients presenting to the emergency department were included in this study over a 28-month recruitment time (Appelboam et al., 2015).

The primary outcome of the research was conversion to a sinus rhythm recorded on an ECG with in one minute of the maneuver attempt (Appelboam et al., 2015) (Appendix B – 1). Both groups performed a Valsalva maneuver for 15 seconds creating a minimum pressure of 40 mmHg. This was measured using an aneroid manometer which allows the participant and evaluator to visualize the target pressure. The SVM was performed in the semi-recumbent position (45-degree angle) and remaining in that position at least one minute afterwards. The modified vagal maneuver (MVM) was started in the same semi-recumbent position but then immediately after the 15 second strain, the patients head was lowered to a flat position and legs were passively raised to a 45-degree angle for 15 seconds, then the legs lowered flat the head raised back to a semi-recumbent position for 45 seconds, before reanalyzing the heart rhythm. It was found that

17% of the SVMs met the primary goal of conversion within one minute, while the MVMs achieved conversion at a rate of 43%. After a second attempt of the maneuver, it was found that SVMs converted 4.2% of the time and MVMs converted 8.4% of the time. No disadvantages or serious events were found in this study. There was a substantial reduction in the number of patients requiring other emergency treatments including adenosine administration. Overall, a cost-free, simple, well tolerated postural modification of the SVM was found highly effective (Appelboam et al., 2015).

When assessing the integrity of the study using the CASP questionnaire (Appendix C, Table C – 1), the trial addressed a clearly focused issue in which all of the participants were randomized to treatment. It was noted that treating clinicians could not practically be masked to the allocation. All analyses were done by investigators masked to treatment allocation (Appelboam et al., 2015). The groups were similar at the start of the trial and the results can be applied to adult patients presenting to the emergency department in stable SVT. It was concluded that the benefits outweigh the risks of performing the non-pharmacological intervention of a vagal maneuver in stable SVT.

Similarly, Corbacioglu et al. (2017) (Appendix A – 2) conducted a randomized control trial aimed at detecting whether the MVM is more effective than the SVM in terminating SVT (Corbacioglu et al., 2017). This was a quantitative study with a single center, prospective, randomized control design. The study was conducted in an emergency department in Turkey with data collected from December 1, 2015 to December 31, 2016. Random sampling was performed with sample size of 56, which consisted of 18 to 65-year-old patients presenting to the emergency department in SVT.

All participants were screened and appropriately consented prior to the study. The inclusion criteria were adults and a confirmation of SVT with a heart rate between 140 and 220 beats per minute. Exclusion criteria was as follows, patients who were hemodynamically unstable, had detected atrial fibrillation or atrial flutter, contraindication to VM, pregnancy, obesity (BMI >30), using parasympathomimetic drugs, spontaneous conversion, or who did not agree to participate in the study. The SVM and MVM interventions both employed a 10-mL syringe to move the plunger to achieve the goal of 40mmHg of intrathoracic pressure. During the SVM interventions, the patients sat up vertically, blew into the syringe for 15 seconds and ECG was monitored during the 45 seconds after the maneuver. During MVM interventions, the patients performed the SVM as previously discussed, but then were suddenly brought to a supine position and their legs were raised at a 45-degree angle by the researcher while the ECG was monitored for 45 seconds after the maneuver (Corbacioglu et al., 2017).

The primary outcome was defined as comparing the success rate of conversion and discharge from the ED after SVM and after MVM (Corbacioglu et al., 2017) (Appendix B – 2). Secondary outcomes were defined as the use of any rescue treatment for SVT and any adverse events during either procedure. It was found that 10.7% of the patients converted after the use of the SVM and 42.8% after MVM. The number of patients needing any rescue treatment after the maneuver was found to be 89.3% of the SVM group and 57.1% of the MVM group. No serious side effects were found in either group. One patient in each group experienced dizziness or dyspnea, which was not found to be statistically significant. Overall, Corbacioglu et al., (2017) found that the MVM was more successful in conversion of SVT and indirectly reducing the need for anti-arrhythmic medication than the SVM.

When assessing the integrity of the study using the CASP questionnaire (Appendix C, Table C – 2), the trial addressed a clearly focused issue in which all of the participants were randomized to treatment. It was noted that due to the nature of the procedure that clinicians and patients were not blind to the treatment options as they needed to perform the technique (Corbacioglu et al., 2017). The groups were similar at the start of the trial and the results can be applied to adult patients presenting to the emergency department in stable SVT. It was concluded that the benefits outweigh the risks of performing the non-pharmacological intervention of a vagal maneuver in stable SVT.

Ceylan et al. (2019) (Appendix A – 3) conducted a single center, prospective, randomized control trial, with a purpose of assessing the effectiveness of SVM, MVM, and Carotid Sinus Massage (CSM), in the conversion of sinus rhythm and success at sustaining sinus rhythm in ED patients presenting with SVT. The study took place in the department of emergency medicine, Sanliurfa Research and Training Hospital, Sanliurfa, Turkey, with a sample size of 98 adults. Patients who met the inclusion criteria were randomly assigned (1:1:1) to undergo MVM in group 1, SVM in group 2, and CSM in group 3 using the block randomization method with a block size of 12. All vagal maneuver were performed with continuous cardiac monitoring. If the vagal maneuver was successful, a 12-lead ECG was recorded if return to sinus rhythm was achieved at 0, 1, and 5 min. If there was no recurrence of SVT at the end of the 2-hour observation period, the patient was discharged with recommendations. Any adverse events were recorded, the applied maneuver and results, the time period from the beginning of symptoms, and the patients' demographic variables (e.g., age and sex), vital signs, ECGs, and medical treatment needed.

The CSM group placed the patient in a supine position with the head tilted to the opposite side, located the carotid sinus just below the angle of the mandible and applied finger pressure with a massaging motion first in an upward and downward direction then posteriorly and medially to compress the carotid sinus between the examiner's fingers and the patient's cervical vertebra for 10 seconds. If that was unsuccessful after 1–2 min, the carotid sinus on the opposite side was massaged in a similar manner. The first side selection was based on the nondominant hemisphere of the patient's brain. In the SVM group, the researcher asked the patient to take a deep breath and push a plunger by blowing into a syringe connected to a sphygmomanometer for 20 seconds. The patient was required to reach an airway pressure of 30–40 mm Hg. Standardized verbal instructions were used to help the participant achieve the target pressure and strain duration. In the MVM group, the researcher first applied SVM procedure. Then, the researcher suddenly brought patient to a supine position, and raised the patient's legs to a 45-degree angle (Ceylan et al., 2019).

The primary outcome of the study was comparison of the sustained success rates at the fifth minute of the application of the maneuver. The secondary outcome was comparison of the success rates immediately after the intervention and at the first minute of the application of the maneuver (Ceylan et al., 2019) (Appendix B – 3). The authors found that the MVM was more effective at converting to sinus rhythm than SVM and CSM (43.7%, 24.2%, and 9% respectively). Also, MVM had a higher conversion success rate at the first and fifth minute than SVM and CSM (37.5%, 12.1%, and 6.1%; 28.1%, 6.1%, and 3.0%, respectively) (Ceylan et al., 2019).

When assessing the integrity of the study using the CASP questionnaire (Appendix C, Table C – 3), the trial addressed a clearly focused issue in which all of the participants were randomized to treatment by the block randomization method in order to prevent bias, but the mean age of the patients who had MVM was found to be significantly lower. The study was not blind because of the nature of the maneuvers (Ceylan et al., 2019). The groups were similar at the start of the trial and the results can be applied to adult patients presenting to the emergency department in stable SVT. It was concluded that the benefits outweigh the risks of performing the non-pharmacological intervention of a vagal maneuver in stable SVT.

Cross-Study Analysis

The cross-study analysis table (Appendix D) exhibits the vagal maneuver intervention used for each study, as well as the major outcomes investigated including: conversion of SVT to a sinus rhythm. Appelboam et al. (2015) compared the efficacy of SVM to MVM in the termination of SVT post intervention at the 1-minute mark, with a secondary outcome of the use of any emergency treatment the need and reason for admission stay, the length of time participants spent in the emergency department, and adverse events. Corabacioglu et al. (2017) compared the success rate of achieved sinus rhythm and discharge from of ED after SVM and after MVM and secondary outcomes were defined as the use of any rescue treatment for SVT and any adverse events during either procedure. Ceylan et al. (2019) compared SVM and MVM, as well as a third vagal maneuver the CSM and assessed for successful conversion to sinus rhythm post intervention at the 1 minute and 5-minute mark.

All studies used the SVM or MVM for the conversion of stable SVT to a sinus rhythm. Study 1 found SVM successful in 17% of patients while study 2 resulted 10.7%, and study 3 found 24.2% at the end of the first minute. Study 3 found SVM to be successful 12.1% at the end of the fifth minute. The superior intervention was found to be MVM in all studies; Study 1 found 43%, study 2 found 42.9%, and study 3 found 43.7% conversion rate at the end of the first minute. Study 3 found MVM to be successful 37.5% of the time at the end of the fifth minute. Study 3 also found that CSM was successful 9% at the first minute and 3% at the fifth minute.

Study 1 found the SVM group had Adenosine administered 69% of the time while study 2 found 30.4%. Study 1 found the MVM group had Adenosine administered 50% of the time while study 2 found19.6%. Study 1 found the SVM group required emergency treatment 80% of the time while study 2 found 89.3%. Study 1 found the MVM group required emergency treatment 57% of the time while study 2 found 57.1%. Study 1 found adverse events in the SVM group 4%, while study 2 found 7.1%. Study 1 found adverse events in the MVM group 6%, while study 2 found 7.1%.

Next, the summary and conclusions will be presented.

Summary and Conclusions

Supraventricular tachycardia involves a re-entrant movement of electrical activity through the AV node in the heart (Taylor & Wong, 2004). The goal of all SVT treatment modalities is to slow AV node conduction enough to interrupt the re-entrant movement and allow the emergence of underlying sinus node activity (Taylor & Wong, 2004). Supraventricular tachycardia is usually episodic in nature and the patient may be asymptomatic or experience a wide range of symptoms including palpitations, shortness of breath, chest pain, anxiety, nausea, dizziness, or presyncope (Smith, Dyson, et al., 2015). Farkowski et al., 2016, conducted a study analyzing the cost and contributing factors of medical treatment for SVT. The authors found that even though SVT in most cases is benign in nature, it results in a significant impairment of health-related quality of life. There are often recurrent episodes of arrythmias which require repetitive consultations, hospitalizations, and diagnostic tests which contributes to the overall cost of medical treatment of SVT (Farkowski et al., 2016).

The initial management of acute stable SVT varies greatly from no intervention to the use of vagal maneuvers or pharmacological therapies (Smith, Dyson, et al., 2015). The vagal maneuver intervention stimulates the Vagus nerve to create a substantial increase in cardiac parasympathetic tone, which slows the electrical conduction through the AV node (Taylor & Wong, 2003). Recent evidence, such as that of Bibas et al., 2016, recommends beginning with the nonpharmacologic approach because it may preclude the need for adenosine. This approach may identify patients who respond to the vagal maneuver and who can be taught to use it during future episodes. Vagal maneuvers have been found to be cost-free, simple, well tolerated, and have no adverse effects

(Appelboam et al., 2015). If the provider chooses to treat with pharmacologic interventions there may be adverse events such as hypotension or palpitations that can cause discomfort for the patient and may require treatment for correction (Dogan et al., 2015). Therefore, the use of vagal methods as a first line treatment may prevent the patient from receiving unnecessary medication that may cause harm or discomfort.

The purpose of this systematic review was to compare the effectiveness of standard vagal to modified vagal methods in adults for conversion of stable SVT to a sinus rhythm. A comprehensive literature review was completed using PubMed and CINAHL, focusing on vagal methods in the termination of stable supraventricular tachycardia. The theoretical framework used for this systematic review was PRISMA, a four-phase flowchart compromised of a 27-item checklist. Analytical and unbiased evaluation of each RCT was ensured through this checklist (Moher et al., 2009).

Upon narrowing down the search results, individual study analysis was conducted on three studies that met the inclusion criteria. Key information from each study was incorporated into individualized study data tables. Data outcome tables were then developed to analyze the effectiveness of vagal maneuvers in the termination of SVT in adult patients presenting to the emergency department. Next, the Critical Appraisal Skills Programme (CASP) checklist was used to appraise the individual RCTs. Finally, a cross study analysis table was developed comparing the efficacy of the standard vagal maneuver to the modified vagal maneuver in the termination of SVT.

The findings of this systematic review determined that the modified vagal maneuver is more successful in the conversion of SVT to a sinus rhythm than the standard vagal maneuver. Appelboam et al. (2015) found that the MVM had an increased rate of reversal compared to the SVM in SVT. Corbacioglu et al. (2017) was able to replicate those findings with a similar RCT, showing the MVM to be superior to the SVM. Additionally, Ceylan et al. (2019) was able to produce comparable findings of MVM having a higher success rate of conversion than the SVM, the authors also studied the CM which had the lowest conversion rate. Each study found no associated adverse events in the use of either MVM or SVM. Through analysis of these studies a major potential barrier to the success of MVM in the conversion of SVT is variations of the technique. It is imperative that the instruction of vagal methods be uniform. A limitation recognized when completing this systematic review was the sample size of each study, ideally a larger sample size would help with generalization and application of the findings to the public. Lastly, this study found that there is a significant lack of literature on vagal methods, more research, specifically RCTs will need to be conducted to help make a practice change in the health care system.

Next, the recommendations and implications for advanced nursing practice will be presented.

Recommendations and Implications for Advanced Nursing Practice

Supraventricular tachycardia is responsible for 50,000 emergency department visits annually (Murman et al., 2007). With this type of impact on the already stressed hospital systems, it is imperative that we work to reduce the number of ED visits and hospitalizations. Taylor and Wong (2004), conducted a multicenter observational study in Australia, with the purpose of asking emergency department doctors how they would instruct a patient to perform a vagal maneuver presenting in SVT. Inadvertently, it was found that ED physicians had a tendency to neglect the recommended first line intervention of vagal maneuvers and instead jumped to the use of adenosine and calcium channel blockers, which reiterates the need for more research to be conducted on vagal maneuvers to implement evidence-based practice guidelines for the treatment of stable SVT.

Taylor and Wong found that only 9.6% of ED doctors would position their patient correctly and instruct them to blow for the minimum 15 seconds necessary to produce a maximal vagal response for conversion (Taylor & Wong, 2004). The use of vagal maneuvers decreases the number of patients who experience drug therapy complications; however, it has also been found to have variable success rates in the conversion of SVT (Taylor & Wong, 2004). The authors states that the varying instruction may be a significant contributor to the reported low success rates of vagal maneuvers. Overall, Taylor and Wong concluded that if correct patient instruction is accomplished, improved SVT conversion rates may result and more invasive techniques could be avoided. Additionally, if patients are adequately educated in the correct VM technique, a greater number may be able to independently terminate their arrhythmia shortly after its onset, therefore avoiding the need for ED management (Taylor & Wong, 2004).

Achieving consistency of the vagal maneuver technique is difficult with the lack of scientific literature. There is a new technique called the reverse vagal maneuver (rVM), a case report was published in the Journal of Emergency Medicine in 2020 by Gaudart et al. The authors state to perform the rVM the patient must be in a sitting position and exhale without force, then attempt to inhale against resistance for 10 seconds while pinching their nose and closing their mouth tightly (Gaudart et el., 2020). If the rVM is effective, the resolution of SVT is accomplished within the next 10 to 15 seconds. The rVM results in both an increase in vagal tone and a decrease in sympathetic activity responsible for bradycardia and arterial hypotension, which leads to SVT resolution (Gaudart et el., 2020).

Gaudart et al., states that the rVM is simple to perform, instructions can be given through telephone and can be carried out alone by the patient, which is an aspect that was not possible with the MVM. The rVMs simplicity and ability to be performed autonomously by the patient are important elements due to the significant prevalence of SVT in the population (Gaudart et el., 2020). A primary goal of the rVM is to increase the non-invasive therapeutic arsenal of emergency physicians so that they can rapidly arrest SVT episodes and avoid patient hospitalization (Gaudart et el., 2020).

The American Heart Association has included shared decision making in their 2016 SVT treatment guidelines. It is imperative that the patient be an active participant in the clinical decision-making process including preferences and goals of therapy, while also considering unique physical, psychological, and social situations (Page et el., 2015). The AHA guidelines include personalized, self-directed interventions such as vagal maneuvers. In order to reduce emergency department utilization, the patient must have clear instructions and knowledge of the goals of vagal maneuvers. By empowering the patient through education of self-directed therapy, they may gain the confidence needed to successfully perform the vagal maneuver at home and feel safe while doing so. This systematic review concluded that the MVM had a higher success rate than the SVM, therefore the MVM should be the preferred vagal maneuver when appropriate for the patient. Further research is needed to assess the effectiveness of new vagal methods such as the rVM in termination of SVT. Providers such as Advanced Practice Registered Nurses (APRN) and/or physicians, must be given standardized instructions on how to educate and demonstrate the vagal maneuver correctly to patients in order to have successful conversion. Communication with the interdisciplinary team is imperative to the patient’s management of recurrent SVT episodes. Finally, education provided to the patient on how to correctly perform the vagal maneuver is the key to achieving conversion to a sinus rhythm.

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Appendix A

Table A-1

Study Specific Data

Appelboam, A., Reuben, A., Mann, C., Gagg, J., Ewings, P., Barton, A., Lobban, T., Dayer, M., Vickery, J., & Benger, J. (2015). Postural modification to the standard Valsalva manoeuvre for emergency treatment of supraventricular tachycardias (REVERT): A randomized controlled trial. *Lancet*, *386 North American Edition* (10005), 1747–1753. https://doi-org.ric.idm.oclc.org/10.1016/S0140-6736(15)61485-4					
AIM/PURPOSE	DESIGN	SITE	SAMPLE	METHODS	PROCEDURES
To investigate the effectiveness of adding a postural modification technique to the standard Valsalva maneuver for the treatment of SVTs in the ED.	Randomized controlled trial	Emergency Departments in southwest England	428 adult patients with SVT were enrolled in the trial and participated in the primary analysis.	RCT, Parallel-group trial, patients presenting in stable SVT were randomly allocated using a 1:1 ratio to undergo either a MVM or SVM.	Both MVM and SVM groups included a standardized 40mmHg pressure for 15 seconds by forced expiration measured by aneroid manometer with target pressure marked and visible to the participant and treating team. Standardized verbal instructions were used to help participants perform the maneuver adequately. Also, a training video was shown to all participants. The SVM used a semi-recumbent position on a stretcher and to stay in that position for 60 seconds after the SVM was performed and then a 3-lead ECG was obtained. The MVM began the same way but involved laying the patient flat and lifting their legs to a 45-degree angle for 15 seconds immediately after the vagal strain was completed. If the first attempt was unsuccessful a second attempt was made.

Table A-2

Study Specific Data

Corbacioglu, Ş. K., Akıncı, E., Çevik, Y., Aytar, H., Öncül, M. V., Akkan, S., & Uzunosmanoğlu, H. (2017). Comparing the success rates of standard and modified Valsalva maneuvers to terminate PSVT: A randomized controlled trial. *American Journal of Emergency Medicine*, *35*(11), 1662–1665. https://doi-org.ric.idm.oclc.org/10.1016/j.ajem.2017.05.034					
AIM/PURPOSE	DESIGN	SITE	SAMPLE	METHODS	PROCEDURES
To detect whether modified vagal maneuver (MVM) is more effective than the standard vagal maneuver (SVM) in terminating paroxysmal supraventricular tachycardia.	Single center, prospective, randomized control trial.	Kecioren Training and Research Hospital, Department of Emergency Medicine, Ankara, Turkey	56 adults	Participants were divided into two groups, randomly assigned SVM or MVM, as the first treatment with two-dimensional permutation blocks; in the order of arrival of the patients. In both groups; the determined procedure for SVM or MVM was repeated up to three times in patients whose PSVT did not convert to sinus rhythm. In both groups; if the maneuver was unsuccessful after three attempts, anti-arrhythmic medication was administered. The primary outcome was defined to compare the success rate of achieving sinus rhythm after standard VM or modified VM.	Both groups were monitored before intervention, and asked to blow into 10-mL syringes to move the plunger to achieve the recommended intrathoracic pressure, 40 mm Hg, for optimum VM. In the SVM group, while the patient sat up vertically, the researcher asked the patient to take a deep breath and try to push the plunger by blowing into the syringe for 15 s. During the 45 s after the maneuver, the patient's response was assessed by ECG monitoring. In the MVM group, while the patient sat up vertically, the researcher also asked the patient to take a deep breath and try to push the plunger by blowing into the syringe for 15 s. Then, the patient was suddenly brought to a supine position and his/her legs were raised at a 45- degree angle by the researcher. During the next 45 s, the patient's response was assessed by ECG monitoring. In both groups, the procedure for SVM or MVM was repeated up to 3 times in unresponsive patients. In both groups, if the maneuver was unsuccessful after 3 attempts, rescue medication and anti-arrhythmic treatment were administered according to guidelines

Table A-3

Study Specific Data

Ceylan, E., Ozpolat, C., Onur, O., Akoglu, H., & Denizbasi, A. (2019). Initial and Sustained Response Effects of 3 Vagal Maneuvers in Supraventricular Tachycardia: A Randomized, Clinical Trial. *Journal of Emergency Medicine (0736-4679)*, *57*(3), 299–305. https://doi-org.ric.idm.oclc.org/10.1016/j.jemermed.2019.06.008					
AIM/PURPOSE	DESIGN	SITE	SAMPLE	METHODS	PROCEDURES
To assess the effectiveness of SVM, MVM, and Carotid Sinus Massage (CSM), in the conversion of sinus rhythm and success at sustaining sinus rhythm in ED patients presenting with SVT.	Single center, prospective, randomized control trial.	Department of Emergency Medicine, Sanlıurfa Research and Training Hospital, Sanlıurfa, Turkey	98 adults	Patients who met the inclusion criteria were randomly assigned (1:1:1) to undergo MVM in group 1, SVM in group 2, and CSM in group 3 using the block randomization method with a block size of 12. All vagal maneuver were performed with continuous cardiac monitoring. If the vagal maneuver was successful, a 12-lead ECG was recorded if return to sinus rhythm was achieved at 0, 1, and 5 min. If there was no recurrence of SVT at the end of the 2-h observation period, the patient was discharged with recommendations. Any adverse events were recorded, the applied maneuver and results, the time period from the beginning of symptoms, and the patients' demographic variables (e.g., age and sex), vital signs, ECGs, and medical treatment needed.	The CSM group placed the patient in a supine position with the head tilted to the opposite side, located the carotid sinus just below the angle of the mandible and applied finger pressure with a massaging motion first in an upward and downward direction then posteriorly and medially to compress the carotid sinus between the examiner's fingers and the patient's cervical vertebra for 10 s. If that was unsuccessful after 1–2 min, the carotid sinus on the opposite side was massaged in a similar manner. The first side selection was based on the nondominant hemisphere of the patient's brain. In the SVM group, the researcher asked the patient, who was sitting vertically, to take a deep breath and push a plunger by blowing into a syringe connected to a sphygmomanometer for 20 s. The patient was required to reach an airway pressure of 30–40 mm Hg. Standardized verbal instructions were used to help the participant achieve the target pressure and strain duration. In the MVM group, first applied SVM procedure. Then, the researcher suddenly brought patient to a supine position, and raised the patient's legs to a 45^0 angle.

Appendix B

Table B-1

Outcome Data Collection

Study 1: Appelboam, A., Reuben, A., Mann, C., Gagg, J., Ewings, P., Barton, A., Lobban, T., Dayer, M., Vickery, J., & Benger, J. (2015). Postural modification to the standard Valsalva manoeuvre for emergency treatment of supraventricular tachycardias (REVERT): A randomized controlled trial. *Lancet, 386 North American Edition* (10005), 1747–1753. https://doi-org.ric.idm.oclc.org/10.1016/S0140-6736(15)61485-4				
VARIABLES	Group 1 Standard VM (n=214)	Group 2 Modified VM (n=214)	*p*-value	Significance
Presence of Sinus rhythm at 1min after VM	37 (17%)	93(43%)	<0.0001	93 (43%) of 214 participants in the modified Valsalva maneuver group versus 37 (17%) of 214 participants in the standard Valsalva maneuver group achieved the primary outcome of sinus rhythm at 1 min (odds ratio [OR] 3·7, 95% CI 2·3–5·8; p<0·0001; table 2). The absolute difference was 26·2%; thus, three patients needed the modified Valsalva maneuver to avoid one case of further treatment.
Adenosine given	148 (69%)	108 (50%)	0.0002	
Any emergency anti-arrhythmic treatment	171 (80%)	121 (57%)	<0.0001	
Discharged home from emergency department	146 (68%)	134 (63%)	0.28	
Any adverse event	8 (4%)	13 (6%)	0.32	
Time in emergency department (h; median; IQR	2.83 (1.95-3.62)	2.82 (1.95-3.77)	0.31	

Table B-2

Outcome Data Collection

Study 2: Corbacioglu, Ş. K., Akıncı, E., Çevik, Y., Aytar, H., Öncül, M. V., Akkan, S., & Uzunosmanoğlu, H. (2017). Comparing the success rates of standard and modified Valsalva maneuvers to terminate PSVT: A randomized controlled trial. *American Journal of Emergency Medicine*, *35*(11), 1662–1665. https://doi-org.ric.idm.oclc.org/10.1016/j.ajem.2017.05.034				
	Standard Vagal Maneuver n = 28	Modified Vagal Maneuver n = 28	Mean diff.	Confidence Interval with 95%
Achieving sinus rhythm	3 (10.7%)	12 (42.9%)	32.2%	6.8-53
Rescue treatment	25 (89.3%)	16 (57.1%)	32.2%	6.8-53
Adenosine given	17 (30.4%)	11 (19.6%)	10.8%	-14-34
Other AA treatment	9 (32.1%)	4 (14.3%)	17.8%	-6.7-40
Adverse event	2 (7.1%)	2 (7.1%)	__	Not Significant

Table B-3

Outcome Data Collection

Study 3: Ceylan, E., Ozpolat, C., Onur, O., Akoglu, H., & Denizbasi, A. (2019). Initial and Sustained Response Effects of 3 Vagal Maneuvers in Supraventricular Tachycardia: A Randomized, Clinical Trial. *Journal of Emergency Medicine (0736-4679)*, *57*(3), 299–305. https://doi-org.ric.idm.oclc.org/10.1016/j.jemermed.2019.06.008				
	Modified Vagal Maneuver n = 32	Standard Vagal Maneuver n = 33	Carotid Sinus Massage N = 33	*p* Value
Achieving sinus rhythm at first response	14 (43.7%)	8 (24.2%)	3 (9.1%)	0.006
First minute	12 (37.5%)	4 (12.1%)	2 (6.1%)	0.003
Fifth minute	9 (28.1%)	2 (6.1%)	1 (3%)	0.004

Appendix C

Table C-1

Study 1: Appelboam, A., Reuben, A., Mann, C., Gagg, J., Ewings, P., Barton, A., Lobban, T., Dayer, M., Vickery, J., & Benger, J. (2015). Postural modification to the standard Valsalva manoeuvre for emergency treatment of supraventricular tachycardias (REVERT): A randomized controlled trial. *Lancet*, *386 North American Edition* (10005), 1747–1753.

A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients to treatments randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X Treating clinicians could not practically be masked to the allocation. Trial paperwork and explanations disguised from participants which was the study intervention and which was the control by use of descriptive terms for each Valsalva maneuver. All analyses were done by investigators masked to treatment allocation.
5. Were the groups similar at the start of the trial?	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?	17% of participants in the SVM converted to sinus rhythm compared to 43% in the MVM group.		
8. How precise was the estimate of the treatment effect?	The treatment was confirmed through EKG, either successful or not.		

C. Will the results help locally?	Yes	Can't tell	No
9. Can the results be applied in your context?	X		
10. Were all clinically important outcomes considered?	X		
11. Are the benefits worth the harms and costs?	**X**		

Critical Appraisal Skills Programme (CASP) Randomized Control Trials Checklist

Table C-2

Study 2: Corbacioglu, Ş. K., Akıncı, E., Çevik, Y., Aytar, H., Öncül, M. V., Akkan, S., & Uzunosmanoğlu, H. (2017). Comparing the success rates of standard and modified Valsalva maneuvers to terminate PSVT: A randomized controlled trial. *American Journal of Emergency Medicine*, *35*(11), 1662–1665. https://doi-org.ric.idm.oclc.org/10.1016/j.ajem.2017.05.034

A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients to treatments randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X Randomization with two-dimensional permutation blocks by using opaque-sealed envelopes, prepared by an independent researcher before study period. After determination of the first treatment, an independent researcher controlled next randomization envelope according to randomization sequence.
5. Were the groups similar at the start of the trial?	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?	Three of 28 patients in the SVM group and 12 in the MVM group were returned to sinus rhythm after intervention ($p = 0.007$).		
8. How precise was the estimate of the treatment effect?	The patient's response was asses by ECG monitoring.		
C. Will the results help locally?	**Yes**	**Can't tell**	**No**

9. Can the results be applied in your context?	**X**		
10. Were all clinically important outcomes considered?	**X**		
11. Are the benefits worth the harms and costs?	**X**		

Critical Appraisal Skills Programme (CASP) Randomized Control Trials Checklist.

Table C-3

Study 3: Ceylan, E., Ozpolat, C., Onur, O., Akoglu, H., & Denizbasi, A. (2019). Initial and Sustained Response Effects of 3 Vagal Maneuvers in Supraventricular Tachycardia: A Randomized, Clinical Trial. *Journal of Emergency Medicine (0736-4679)*, *57*(3), 299–305. https://doi-org.ric.idm.oclc.org/10.1016/j.jemermed.2019.06.008

A. Are the results of the trial valid?	**Yes**	**Can't tell**	**No**
1. Did the trial address a clearly focused issue?	X		
2. Was the assignment of patients to treatments randomized?	X		
3. Were all of the patients who entered the trial properly accounted for at its conclusion?	X		
4. Were patients, health workers, and study personnel "blind" to treatment?			X Patient allocation to different maneuvers was decided by the block randomization method in order to prevent bias, but the mean age of the patients who had MVM was found to be significantly lower. The study was not blind because of the nature of the maneuvers.
5. Were the groups similar at the start of the trial?	X		
6. Aside from the experimental intervention, were the groups treated equally?	X		
B. What are the results?	**Yes**	**Can't tell**	**No**
7. How large was the treatment effect?	MVM was more effective at converting sinus rhythm than SVM and CSM (43.7%, 24.2%, and 9% respectively). MVM also had higher conversion success rates at the first and fifth minute than SVM and CSM (37.5%, 12.1%, and 6.1%; 28.1%, 6.1%, and 3.0%, respectively).		
8. How precise was the estimate of the treatment effect?	The patient's response was asses by ECG monitoring.		
C. Will the results help locally?	**Yes**	**Can't tell**	**No**

9. Can the results be applied in your context?	**X**		
10. Were all clinically important outcomes considered?	**X**		
11. Are the benefits worth the harms and costs?	**X**		

Critical Appraisal Skills Programme (CASP) Randomized Control Trials Checklist.

Appendix D

CROSS STUDY ANALYSIS

AUTHOR / YEAR	**COMPARISONS OR PROTOCOL OF STUDY**	**OUTCOME/RESULTS**	**OUTCOME/RESULTS**
Study 1 (Appelboam et al., 2015)	Standard Vagal Maneuver to Modified Vagal Maneuver in the termination of SVT to a sinus rhythm.	Primary outcome was the presence of sinus rhythm as recorded by the treating clinician 1 minute after Valsalva maneuver and confirmed by ECG. Secondary outcomes were the use of adenosine or any other emergency treatment, the need and reason for admission stay, the length of time participants spent in the emergency department, and adverse events. Also compared the adequacy of the Valsalva strain.	17% of participants in the SVM converted to sinus rhythm compared to 43% in the MVM group.
Study 2 (Corbacioglu et al., 2017)	To detect whether modified vagal maneuver is more effective than the standard vagal maneuver in terminating paroxysmal supraventricular tachycardia (PSVT).	Primary outcome was defined as comparing the success rate of achieving sinus rhythm and discharge from of ED after SVM and after MVM. Secondary outcomes were defined as the use of any rescue treatment for SVT and any adverse events during either procedure.	10.7% of patients in the SVM group and 42.9% in the MVM group were returned to sinus rhythm.

Study 3 (Ceylan et al., 2019)	To assess the effectiveness of SVM, MVM, and Carotid Sinus Massage (CSM), in the conversion of sinus rhythm and success at sustaining sinus rhythm in ED patients presenting with SVT.	The primary outcome of the study was comparison of the sustained success rates at the fifth minute of the application of the maneuver. The secondary outcome was comparison of the success rates immediately after the intervention and at the first minute of the application of the maneuver.	MVM was more effective at converting sinus rhythm than SVM and CSM (43.7%, 24.2%, and 9% respectively). MVM also had higher conversion success rates at the first and fifth minute than SVM and CSM (37.5%, 12.1%, and 6.1%; 28.1%, 6.1%, and 3.0%, respectively).