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Review Article

Modified TR Band Application Technique for the Prevention of Hemostasis-Related Complications in Transradial Percutaneous Coronary Intervention (PCI)

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Abstract: The Trans Radial Band (TR Band) is a compression method applied to the radial artery following percutaneous coronary intervention (PCI). Prolonged TR Band removal duration may increase the risk of complications, while premature removal can lead to bleeding. This systematic review aims to evaluate the effectiveness of various modified TR Band application techniques in enhancing hemostasis and preventing vascular complications after transradial PCI. The study followed PRISMA guidelines, with literature searches conducted in PubMed, Scopus, and Google Scholar using specific keywords related to TR Band and its modifications. The results show that several modification techniques—including the use of rollers, slow deflation protocols, dual TR Band application, and hemostatic patches made from chitosan and potassium ferrate—generally improve hemostatic effectiveness, reduce hematoma incidence, and enhance patient comfort. However, limitations such as small sample sizes and the lack of long-term data remain challenges. Conclusion: Modified TR Band techniques are considered safe and effective, but larger-scale studies are still needed.

Keywords: TR Band, Hemostatis, Technique Modification, Trans Radial Access

1. Introduction

Coronary heart disease (CHD) remains one of the leading causes of mortality worldwide, including in Indonesia. According to the World Health Organization (WHO), cardiovascular diseases account for over 17 million deaths annually on a global scale. In Indonesia, the 2018 Basic Health Research (Riskesdas) reported a heart disease prevalence of 1.5%, with the highest rates observed in North Kalimantan (2.2%), the Special Region of Yogyakarta (2.0%), and Gorontalo (2.0%). Moreover, data from the Social Security Administration Agency for Health (BPJS Kesehatan) in 2022 indicated that heart disease constituted the largest expenditure in healthcare services, amounting to approximately IDR 12.14 trillion across 15.5 million reported cases. These findings underscore that CHD represents not only a significant public health concern but also imposes a substantial economic burden on the national healthcare system.

Along with the rising prevalence of CHD, the demand for effective and safe interventional procedures has also increased. One commonly performed procedure is Percutaneous Coronary Intervention (PCI), which aims to open occluded coronary arteries through an invasive approach. The transradial artery (TRA) approach has become the preferred method for PCI due to its lower risk of complications compared to the transfemoral access route. Studies by Batra et al. (2020) and Imbrìaco et al. (2022) demonstrated that radial access significantly reduces the risk of major bleeding, accelerates patient mobilization, and shortens hospital stays, thereby enhancing the overall efficiency of healthcare delivery.

Although the TRA is considered safer, challenges remain—particularly in the management of post-procedural hemostasis. Inadequate hemostasis can lead to complications such as hematoma, rebleeding, and radial artery occlusion (RAO). A study conducted at Prof. Dr. R. D. Kandou General Hospital, Manado, reported that out of 352 patients undergoing PCI via transradial access, 15 patients (4.3%) experienced complications. The most common

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complications were radial artery spasm (35.3%), non-coronary arterial dissection (29.4%), and access site hematoma (11.8%). These findings indicate that while TRA is generally safer, post-procedural complications remain a significant clinical concern.

To address these challenges, various compression devices have been developed, one of which is the TR Band. The TR Band is designed to apply optimal pressure to the radial artery without compromising the surrounding structures, thereby minimizing the risk of complications. However, the standard technique for using the TR Band presents several limitations, such as uneven pressure distribution, variable hemostasis times, and the potential for skin or soft tissue irritation. Furthermore, patient comfort during the use of the TR Band is also a critical aspect that is often overlooked in clinical practice.

In recent years, various modifications to the TR Band application technique have been introduced to improve effectiveness, efficiency, and to reduce complication rates. Several studies have explored different modifications to TR Band usage techniques, including the addition of adjunctive materials such as hemostatic patches, gradual deflation techniques, lower initial inflation pressures, modified timing protocols, and other supportive materials. A study by Medranda et al. (2021) demonstrated that the combination of the TR Band with a potassium ferrate patch significantly accelerated hemostasis without increasing the risk of hematoma or RAO.

However, to date, there has been no systematic review that comprehensively analyzes the effectiveness of various TR Band technique modifications on clinical outcomes, particularly in the context of enhancing hemostasis and preventing complications. This systematic review aims to collect, analyze, and evaluate the scientific evidence from published studies. Furthermore, the findings from this review may serve as a basis for clinical decision-making and the development of more effective and safer nursing practice guidelines for patients undergoing PCI with radial access.

2. Method

This systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to identify relevant studies on TR Band modifications in patients undergoing PCI with TRA. Article searches were performed using databases including PubMed, Scopus, and Google Scholar, with the following keywords: "TR Band" AND (modification OR modified) AND hemostasis. Article selection was carried out based on the following inclusion and exclusion criteria:

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles published in the last 5 years (2020–2024)	Articles that cannot be accessed in full text
Articles written in English or Indonesian	Articles irrelevant to the topic of TR Band modification
Articles discussing techniques of TR Band modification	Articles without empirical data or relevant theoretical analysis

The extracted articles will be analyzed qualitatively to identify patterns, key findings, and research gaps. Relevant data will be presented in tabular form to provide a structured overview of the analyzed literature.

3. Results and Discussion

Article searches were conducted through database searches including PubMed, Scopus, and Google Scholar. Based on the inclusion and exclusion criteria, 6 articles were selected following the PRISMA guidelines, as illustrated in the figure. The articles that met the criteria were further analyzed and discussed.

Figure: PRISMA Flow Diagram

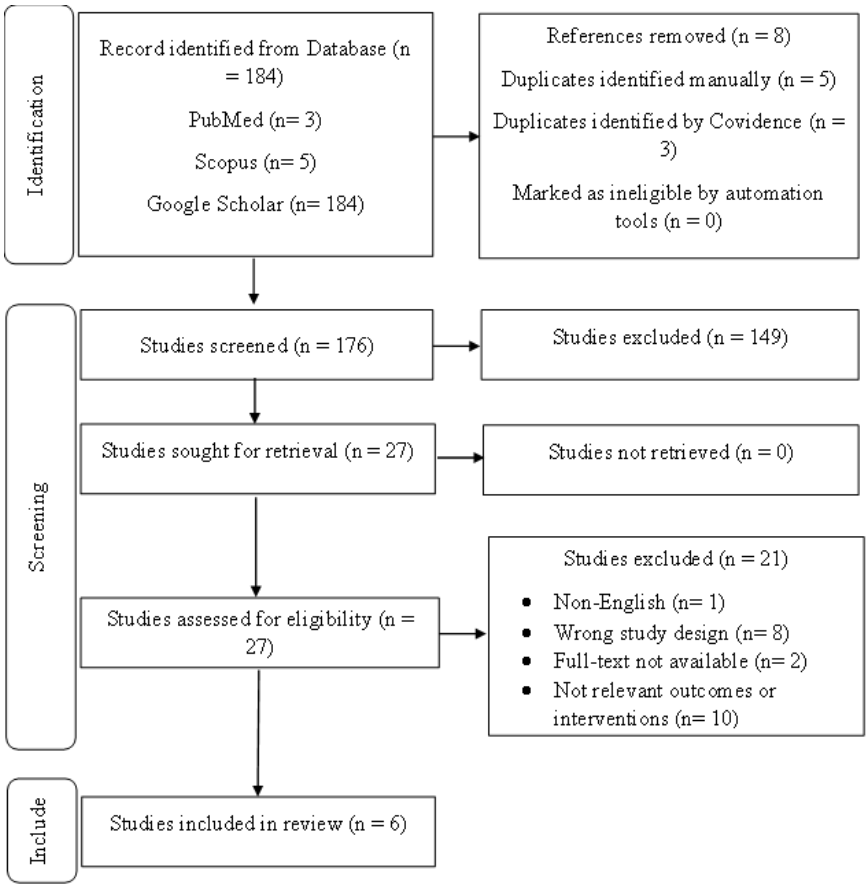

Table 2. Article Data Mapping Resultshis is a table.

Research Title	Objective	Method	Results
Observation on the Effect of Roller-Assisted Balloon Compression Hemostat After PCI (Jia Tao et al., 2022) China	To examine the effect of a balloon hemostasis device with roller assistance to reduce complications post-PCI via radial access	Prospective study on 122 patients divided into two groups: control (standard TR Band) and observation (TR Band with roller). Complication parameters and patient satisfaction were measured.	The roller group showed less swelling, pain, and bleeding compared to control. Patient satisfaction was higher in the roller-modified group.
Feasibility and Immediate Safety of Distal Transradial Access in Coronary Intervention (Subhabrata Dutta et al., 2020) India	To evaluate the feasibility and safety of distal transradial access in coronary angiography	Prospective study on 100 patients undergoing procedures using distal transradial access (dTRA). Hemostasis was performed with a TR Band modified specifically for dTRA.	dTRA access was successful in 96% of cases. No major complications. The TR Band modification specific to dTRA was effective for hemostasis.
Outcomes of a Modified Technique for Deflation of Distal Radial Artery Occlusion	To compare two deflation protocols of a hemostasis device to assess radial artery patency after PCI	Non-randomized, single-center study on 446 patients divided into two groups with different deflation protocols (slow vs. fast). Complication	No significant difference in RAO incidence between standard and fast deflation protocols, but hematoma occurred more

Device After PCI (Aatika Habib et al., 2023) Pakistan		parameters such as RAO and hematoma were measured.	frequently with fast deflation protocol.
Transulnar Catheterization in Patients with Failed Ipsilateral Transradial Access (Shunsuke Aoi et al., 2020) Japan	To evaluate the safety and effectiveness of transulnar access with modified TR Band for hemostasis in patients with failed ipsilateral transradial access	Retrospective study on 10 patients with transulnar access. Modified TR Band was used for dual compression at radial and ulnar sites.	Hemostasis was successful in all patients without major complications. Modified TR Band was effective for dual artery compression (radial and ulnar).
Safe and Rapid Radial Hemostasis Achieved Using a Novel Topical Hemostatic Patch (Rajeev Anchan et al., 2021) India	To evaluate the effectiveness of a chitosan-based hemostatic patch to accelerate hemostasis time after transradial procedure	Prospective study on 50 patients using a hemostatic patch (hm-P patch) combined with TR Band. Hemostasis time and complications were observed.	Hemostasis time reduced to 40.5 minutes without RAO. The hm-P patch improved hemostasis and reduced vascular complications.
Outcomes of a Modified Technique for Hemostasis with Potassium Ferrate Hemostatic Patch (STAT2 Trial) (Olivier F. Bertrand et al., 2022) Canada	To examine the reduction in hemostasis time using a potassium ferrate hemostatic patch compared to standard TR Band	Prospective randomized multicenter trial with 100 patients using potassium ferrate patch combined with TR Band. Hemostasis time and RAO complications observed.	Hemostasis time reduced by 40% compared to standard TR Band without increase in RAO. The hemostatic patch was safe and effective in accelerating hemostasis.

Table 3. Summary of the Effectiveness of Modified TR Band vs Standard TR Band

Modification Technique	Hematoma (%)	RAO (%)	Hemostasis Time
Roller-assisted TR Band	2% vs 8%	0%	20% faster
Slow Deflation	3% vs 7%	1.5% vs 1.8%	Not explicitly measured
Chitosan Patch	0%	0%	40.5 minutes
Potassium Ferrate Patch	1% minor complications	0%	40% faster
Double TR Band	Not reported	Not reported	100% effective hemostasis

4. Discussion

This systematic review identified various modified techniques in the use of the TR Band, demonstrating benefits in improving hemostatic outcomes and reducing post-procedural complications following PCI via transradial access. Several modification strategies showed high effectiveness. The TR Band modification with an added roller (Jia Tao et al., 2022) enabled more even pressure distribution, significantly reducing swelling, pain, and bleeding. The results reported a higher level of patient satisfaction compared to the standard TR Band.

The modification technique for distal transradial access (dTRA) using the TR Band (Aatika Habib et al., 2023) demonstrated a reduction in the incidence of hematoma, although no significant difference was found in the incidence of RAO between the slow and rapid

deflation techniques. This highlights the importance of gradual pressure control to maintain optimal hemostatic outcomes.

For more complex vascular access cases, the modification involving the use of two TR Bands (Shunsuke Aoi et al., 2020) enables simultaneous compression of both the radial and ulnar arteries. This strategy successfully managed failed transradial access without causing major complications. The study demonstrates the flexibility of the TR Band in various clinical settings.

In terms of using additional materials, the combination of the TR Band with a chitosan-based hemostatic patch (Rajeev Anchan et al., 2021) and a patch made of Potassium Ferrate (Olivier F. Bertrand et al., 2022) has been proven to accelerate hemostasis time. Both approaches significantly reduced compression time without increasing the incidence of RAO, thereby offering a safe and effective alternative to expedite patient recovery.

A comparative analysis of TR Band modification techniques aims to identify the advantages, limitations, and optimal applications of each approach. In general, the modification techniques can be categorized into: mechanical modifications (such as the use of rollers and double bands), which focus on improving pressure distribution to reduce pain, enhance patient comfort, and minimize local complications; procedural modifications (such as the slow deflation technique), which target the physiological control of blood flow to maintain arterial patency; and combination modifications (such as the use of hemostatic patches), which are oriented toward accelerating the clotting process to achieve faster hemostasis without increasing vascular risk.

This systematic review has several limitations that should be considered. First, most of the analyzed studies involved relatively small sample sizes, ranging from 10 to 446 patients, which may reduce statistical power and limit the generalizability of the results to a broader population. Additionally, many of the studies employed prospective observational designs or non-randomized controlled trials, thereby increasing the risk of selection bias and reducing the internal validity of the findings.

The majority of the studies were also conducted at a single healthcare center (single-center), which reduces the diversity of the sample population and introduces the possibility of bias related to local practices. The variations in TR Band modification techniques used in these studies, such as the use of rollers, hemostatic patches, slow deflation protocols, and double TR Bands, resulted in high heterogeneity, making direct comparison between techniques difficult and limiting the feasibility of conducting a quantitative meta-analysis.

Furthermore, there are differences in outcome definitions across studies, both in hemostasis parameters and complications assessed, which reduces consistency in the interpretation of results. The lack of long-term follow-up data is also a limitation, as most studies only evaluate immediate post-procedure outcomes without considering potential vascular complications later on, such as late RAO or impaired arterial function.

The results of this systematic review have several important implications for clinical practice. Various modifications of the TR Band are capable of improving hemostasis effectiveness, accelerating bleeding time, and reducing risks such as hematoma and RAO. These modifications can contribute to enhanced patient safety, faster recovery, and shorter hospital stays. From a healthcare service perspective, implementing these modified techniques can increase procedural efficiency, reduce the need for additional interventions due to complications, and optimize hospital resource utilization. Additionally, the improved patient comfort resulting from TR Band modifications has the potential to increase patient satisfaction with hospital services.

It is important to emphasize that before wide implementation, healthcare institutions need to consider the availability of equipment, additional costs that may arise from using hemostatic patches, and the need for training medical personnel to master more complex modification techniques. The development of evidence-based clinical practice guidelines that integrate TR Band modification techniques is a crucial step to ensure consistent, effective, and safe application.

Based on the limitations identified in this review, several important recommendations for future research can be proposed. First, large-scale randomized controlled trials with multicenter designs are needed to strengthen the external validity of findings related to the effectiveness of various TR Band modification techniques. Studies with larger and more representative sample sizes will enhance the generalizability of results to diverse patient populations with varied clinical backgrounds.

There is a need to standardize the definitions of clinical outcomes such as optimal hemostasis time, incidence of hematoma, and RAO, to enable more consistent and accurate

comparisons between studies. Research should also focus on long-term evaluations, including follow-up periods of at least six months to one year, to assess the impact of modification techniques on vascular function and the possibility of late complications.

The use of new hemostatic patches or other innovative techniques should be evaluated not only from the perspective of clinical effectiveness but also cost-effectiveness, to consider the economic implications at a broader healthcare service scale. Finally, qualitative research is needed to explore patient experiences and comfort with these modification techniques, in order to enrich patient-centered care approaches in cardiology interventions.

Thus, overall, all modification techniques analyzed in this study were proven safe, capable of improving hemostasis effectiveness, and reducing post-PCI complication rates compared to the standard TR Band. Although these findings are very promising, limitations such as small sample sizes, non-randomized study designs, and lack of long-term data require cautious interpretation of the results.

5. Conclusions

Modification of TR Band usage techniques has been proven to improve hemostasis effectiveness and reduce complications after PCI via transradial access. Overall, TR Band modification techniques offer significant opportunities to enhance patient safety, procedural efficiency, and quality of care in interventional cardiology practice, as well as providing a strong foundation for the development of evidence-based clinical guidelines in the future.

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