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Original Article

Investigating optimal compression approach following radial artery puncture: a retrospective study

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Abstract: Background: The method for compressing hemorrhagic sites after transradial access has been a topic of interest, yet definitive guidelines remain elusive. This study aims to address this gap by optimizing the mechanical compression hemostasis protocol after transradial access. Methods: This retrospective analysis included 300 patients from the Department of Cerebrovascular Diseases, Shanghai Fourth People's Hospital affiliated to Tongji University, who underwent transradial access for cerebrovascular angiography. Following the procedure, patients received radial artery compression hemostasis using a balloon compressor. They were divided into group A (n=100, continuous deflation) and group B (n=200, intermittent deflation) according to different hemostasis methods. The incidence of bleeding at the puncture site and complications were compared between the two groups. Results: The rate of bleeding at the puncture site was significantly lower in group B (20 out of 200 patients) compared to group A (20 out of 100 patients) (P=0.032). Similarly, the incidence of puncture site complications, such as edema, congestion, and wound infection was lower in group B (5 out of 200 patients) compared to group A (10 out of 100 patients) (P=0.006). Conclusion: Four hours of compression with intermittent deflation (group B) emerged as the optimal compression method after transradial access, demonstrating fewer complications at the patient's puncture site.

Keywords: Transradial access, cerebrovascular diseases, compression approaches, complications

Introduction

Transradial access refers to the technique of puncturing the radial artery to establish endovascular access for coronary diagnosis and treatment, as well as neuro-interventional procedures [1, 2]. First reported by Campeau et al. in 1989 [3], this approach has gained widespread acceptance in clinical practice. In 2021, the American College of Cardiology also recommended in the guideline to use transradial access for managing acute coronary syndrome and stable ischemic heart disease [4]. Relevant studies [5, 6] have confirmed that in addition to cardiovascular interventions, the radial artery approach also offers benefits in treating visceral vascular conditions and is applied in managing splenic, iliac artery, renal, and mesenteric vessel diseases.

Transradial access is widely accepted because of its advantages over femoral artery puncture, including reduced bleeding and vascular complications at the puncture point, improved patient comfort, shorter hospital stay, and notably, decreased patient mortality [7]. Despite its clinical success, a gap exists in standardized and evidence-based guidelines for managing the postoperative puncture site, often leaving practitioners to rely on experience, which could introduce potential risks to patients.

Hemostasis is particularly important when the radial artery is unobstructed. A study has shown that postoperative bleeding at the puncture site and skin damage often occur in patients receiving transradial access [8]. Currently, hemostasis at the puncture site is achieved through the placement of hemostatic devices, including the use of knob or balloon. However, due to the lack of consensus on optimal venting time and amount, these methods all have their shortcomings, leading to potential discomfort and complications for patients, e.g., radial artery

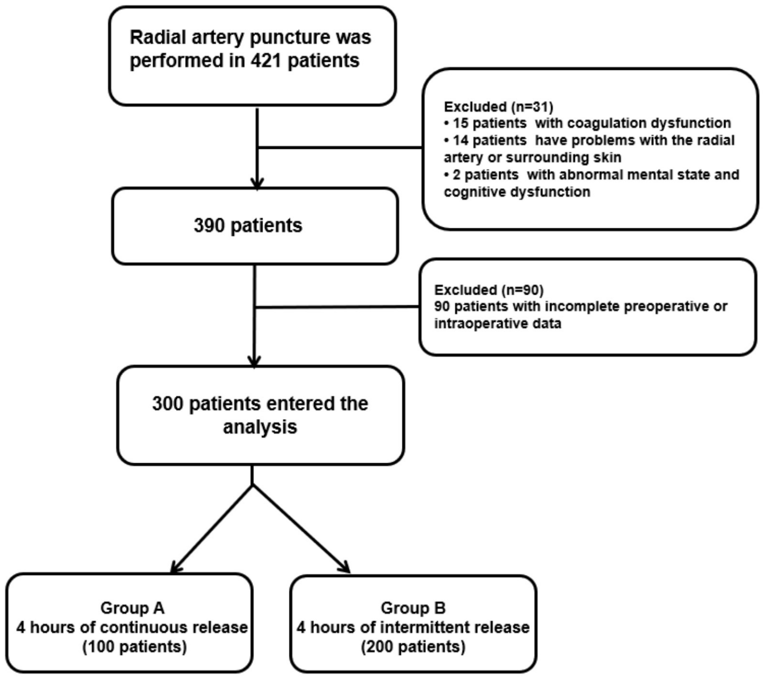

Figure 1. Flow diagram detailing the selection of patients included in this retrospective analysis.

occlusion, poor venous return, bleeding at the puncture point, and skin damage [9-11]. These complications can seriously affect patients' medical experience, and even threaten their lives. Although a large number of scholars have reported methods to deal with complications after radial artery puncture, the precise timing for pressure hemostasis is understudied.

Recent shifts in clinical practice towards intermittent deflation during compression after radial artery puncture [12] and a growing understanding of platelet agglutination dynamics suggest the need for a standardized approach [13]. Therefore, the purpose of our research was to explore venting strategies during compression after radial artery angiography, seeking the optimal compression duration and method to provide reference for standardized patient care post-procedure, improve treatment outcomes, and minimize patient discomfort.

Data and methods

Study design and patients

This retrospective study collected data of 300 patients who underwent cerebrovascular angiography in the Department of Cerebrovascular Diseases at the Fourth People's Hospital Affiliated to Tongji University between January 2023 and October 2023. Patients were divided into group A (n=100) and group B (n=200) according to different methods of gas releasing during compression. Group A was subjected to 4 hours of compression with continuous deflation. Pressure was accumulated during the 4 hours, with a controlled release of 1 mL of gas within the initial hour. The balloon was fully deflated at the third hour, and the entire system was disassembled at the fourth hour. Group B was subjected to 4 hours of compression with intermittent deflation. Here, the pressure was also accumulated during the 4 hours, but 1 mL of gas was released intermittently every hour during the initial 2 hours. The balloon was fully deflated at the third hour, and the entire system was disassembled at the fourth hour. This study was reviewed and approved by the Ethics Committee of Shanghai Fourth People's Hospital affiliated to Tongji University.

Inclusion criteria: Patients with good radial artery pulsation, intact skin at the transradial access site (no damage or infection), normal coagulation dysfunction, clear consciousness before the operation, and complete medical records including current and past medical history, preoperative laboratory and imaging examination results, as well as intraoperative data. Exclusion criteria: Patients with radial artery anomalies, access site issues, coagulation disorders, or cognitive impairments (**Figure 1**).

Data extraction

Preoperative, intraoperative, and postoperative data were all collected from eligible patients. Preoperative data included gender, age, diagnosis, surgical type, pre-surgical medications, radial artery assessment, routine ultrasound

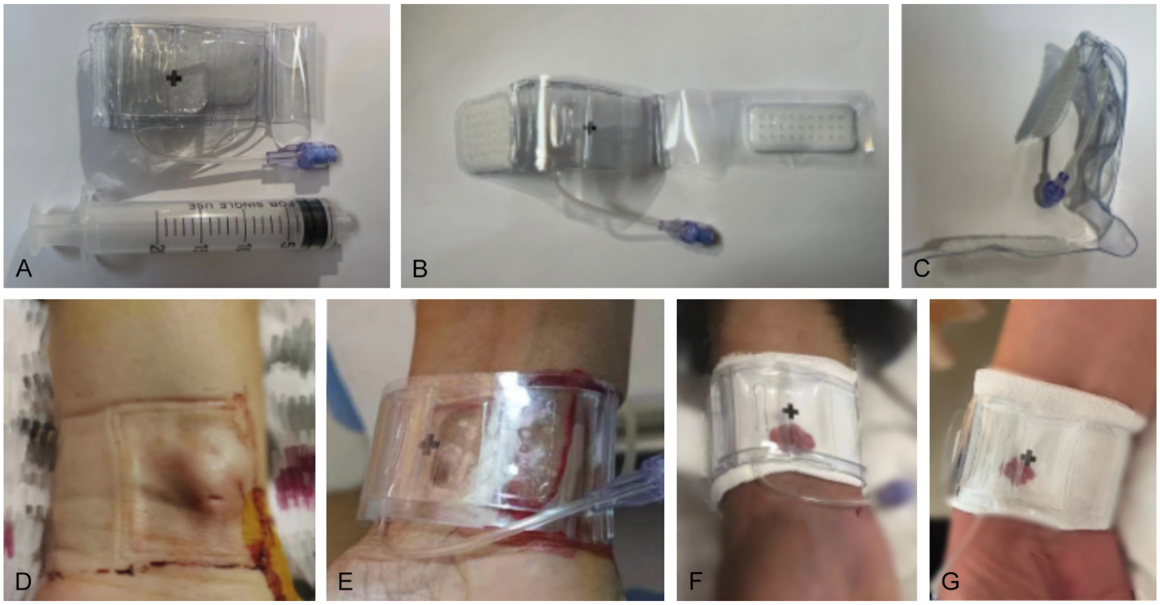

Figure 2. Compressors and postoperative bleeding. A-C. Balloon radial artery compressor. D. Skin injury. E. A situation that requires secondary hemostasis. F and G. Regular radial compression after radial artery puncture surgery.

examination, blood coagulation, and anatomical characteristics of patients. Intraoperative data included anesthesia type, surgery duration, blood pressure, heart rate, the diameter and inflation of the arterial sheath. The printed electronic records were manually reviewed and compared with those from the electronic data acquisition algorithm to assure the data consistency. Postoperative data included venting time, bleeding, and complications. An experienced cerebrovascular specialist (Fang Yibin) further verified the accuracy of the diagnosis.

Outcome measures

Post-surgery, a balloon radial artery compressor (Conde Lai medical device) was used for hemostasis (**Figure 2A-C**). For inflation, 1-2 mL gas was injected into the balloon each time until no bleeding at the puncture site. The primary outcome was bleeding time, defined as blood seepage requiring secondary hemostasis. Secondary outcomes included puncture-related complications like skin injuries (**Figure 2D**), including hematoma, bruising, and infection. In addition, the number of patients requiring secondary hemostasis (**Figure 2E**) and secondary bleeding time in both groups were recorded. Secondary hemostasis occurs in a small number of patients after surgery (**Figure 2F** and **2G**), while most patients have no bleeding at the puncture site. The core steps of our research include: 1. Grouping; 2. Controlling irrelevant factors; 3. Selecting evaluation index; 4. Getting the result (**Figure 3**).

Statistical analysis

Categorical data were expressed as absolute value and rate (%), and the statistical analysis was conducted using chi-squared (χ^2) test or Fisher's exact test, with significance levels set at $P < 0.05$, $^{**}P < 0.01$, $^{***}P < 0.001$.

Results

Comparison of postoperative secondary bleeding between the two groups

Group A had a 24% (24 out of 100) incidence of secondary bleeding, while group B had an incidence of 12% (24 out of 200) (**Figure 4A-C**), with a significant statistical difference between the two groups (P=0.032). It is noteworthy that group A had 2 patients who bled 3-12 hours after surgery, a scenario absent in group B. Also, fewer patients in group B experienced bleeding 2-3 hours after surgery (**Figure 4D** and **4E**).

Comparison of postoperative skin injury at puncture site between the two groups

Skin injuries include blood seepage, infection, hematoma, and vascular occlusion. Group A

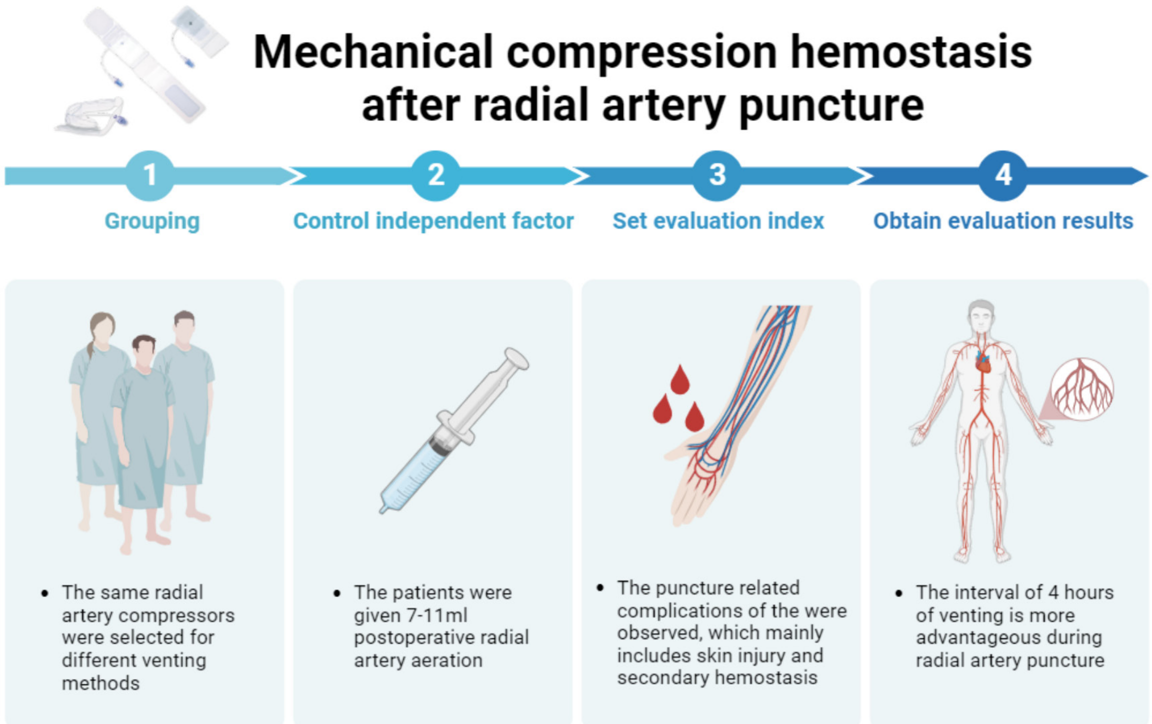

Figure 3. Research process.

exhibited a 10% incidence of skin injuries, whereas group B showed a reduced rate of 2.5%, with significant statistical difference between the two groups (P=0.006) (**Figure 5A-C**).

Detailed breakdown showed 5 cases of blood seepage in group A compared to 3 in group B; wound infection was found in 1 patient from each group; hematomas occurred in 2 patients in group A and 1 in group B. Notably, two patients with radial artery occlusion were recorded in group A. These results underscore that group B experienced fewer skin-related complications, evidencing a lower risk of such issues compared to group A (**Figure 5D** and **5E**).

Discussion

In contemporary healthcare, cardiovascular diseases consistently top the list in terms of incidence, mortality and disability rate, with cardiovascular diseases emerging as a leading cause of death globally [14]. In recent years, with the advancement of coronary intervention technologies, the prognosis of patients with coronary heart disease has been greatly improved, and the mortality and disability rates have been reduced [15], highlighting the importance of cerebrovascular angiography as the diagnostic gold standard. The angiography can be completed through the femoral artery, radial artery, ulnar artery, brachial artery, and other approaches. The common approaches in clinical practice are radial artery and femoral artery puncture. In particular, radial artery access is of significance in improving the safety of neurointerventional surgeries [5]. Although studies have focused on the success rate of puncture and the time required for puncture operation, etc. [10], there are few studies on the postoperative management, including the prevention and response to complications. Complications like bleeding at the puncture site, and hematoma, though not typically severe, can detract from the patient's medical experience. More serious, albeit rare, complications such as radial artery occlusion, false aneurysm, arteriovenous fistula, and forearm compartment syndrome [16] pose significant health risks.

Complications after radial artery puncture are caused by either insufficient oppression or excessive oppression, underscoring the importance of optimizing compression time and

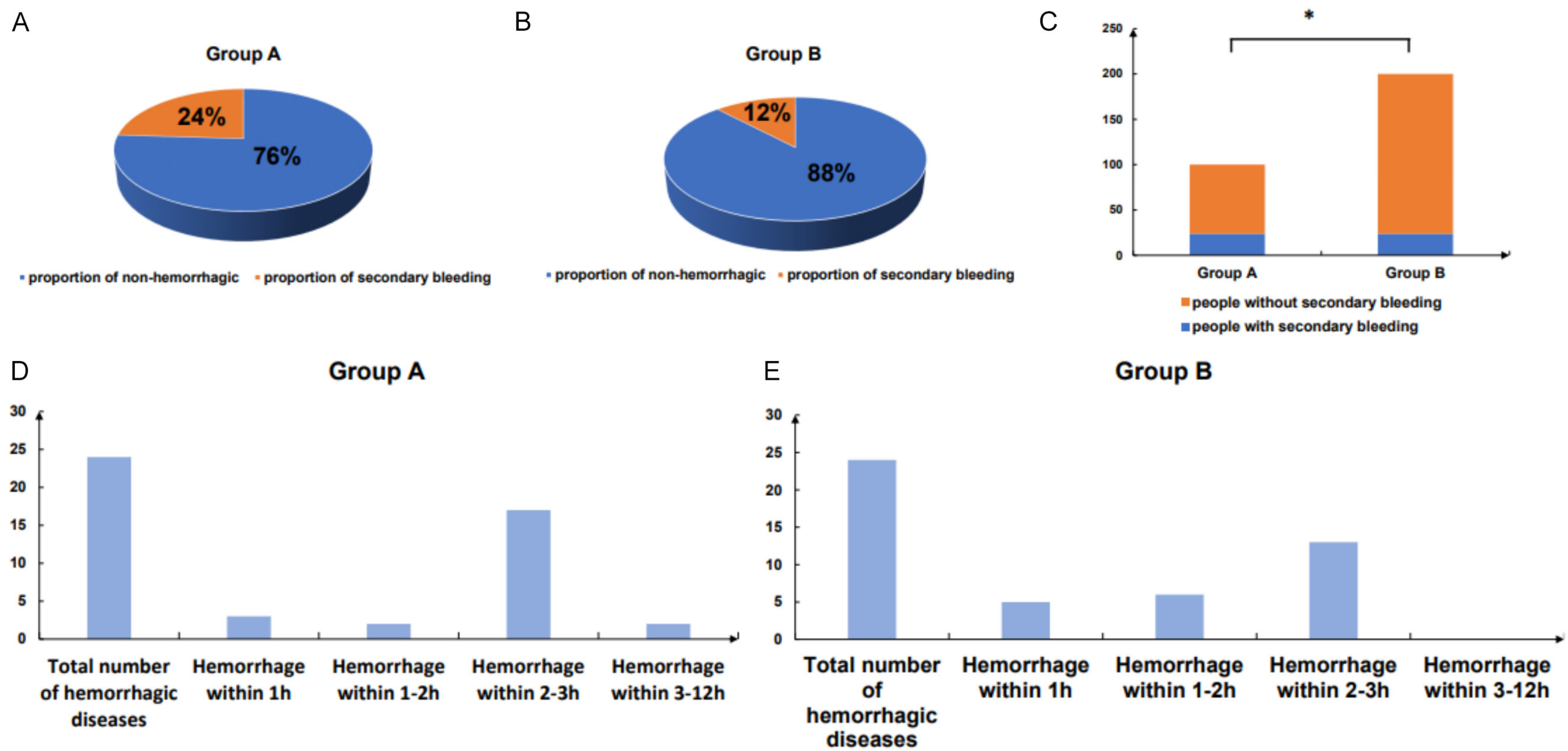

Figure 4. Comparison of secondary bleeding. A-C. Comparison of bleeding amount between the two groups. D and E. Comparison of postoperative bleeding time between the two groups (*P < 0.05).

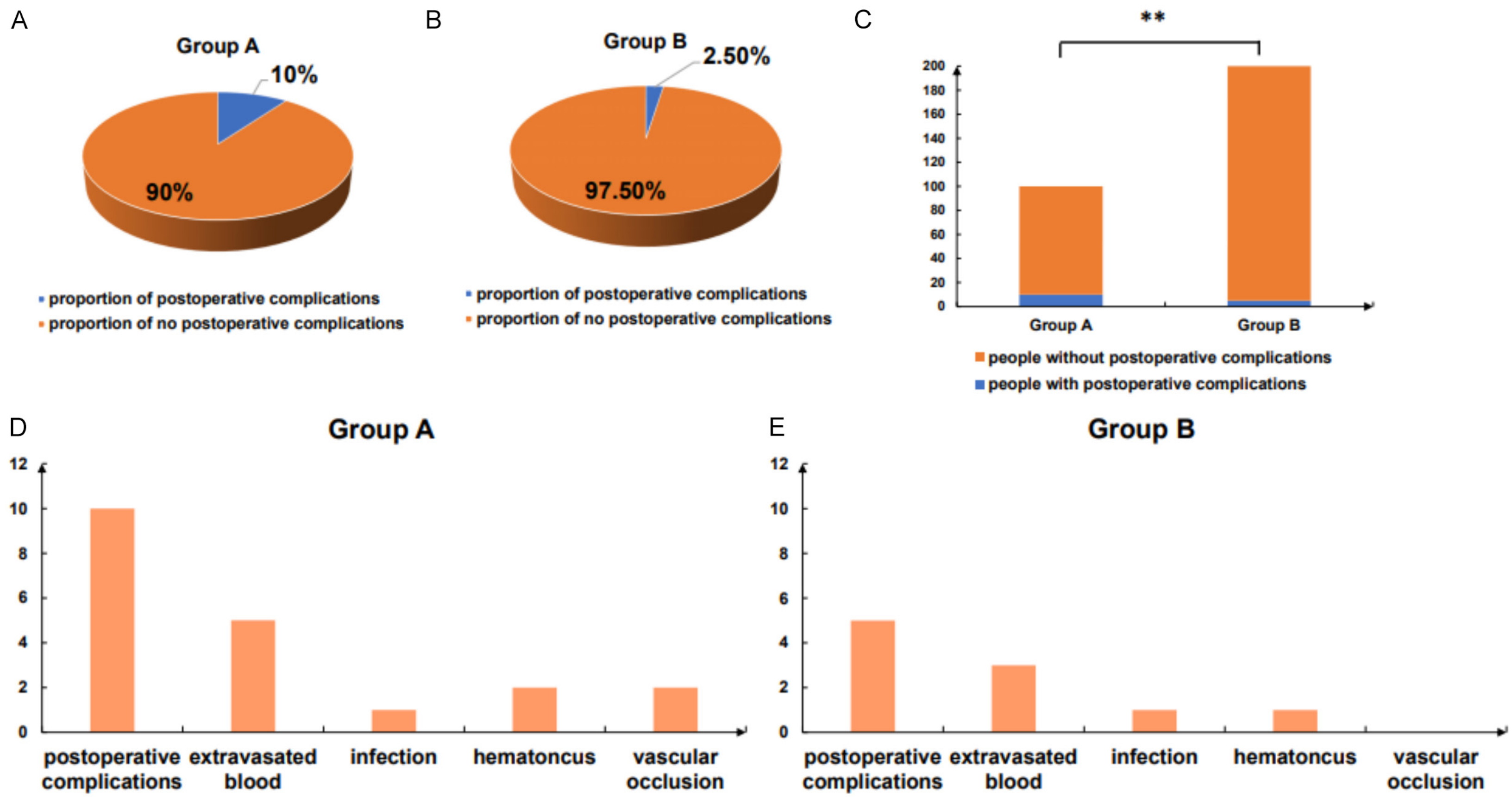

Figure 5. Complications other than bleeding. A-C. Comparison of complications other than bleeding between the two groups. D and E. The number of complications other than bleeding in the two groups (*P < 0.05).

intensity [17]. It is worth noting that in our study 2 out of the 300 patients had radial artery occlusion, which is a very serious complication of radial artery puncture. The clinical manifestations were not obvious radial artery pulsation, slightly low radial finger skin temperature, no pain and paraesthesia, but it requires revascularization treatment, which is extremely painful for patients. The primary risk factors for this complication include diabetes mellitus, congenital stenosis of the radial artery, and intraoperative heparin dosage, which are also related to the compression time and intensity. Our findings confirmed that the compression time and intensity are factors related to the occurrence of radial artery occlusion, and intermittent deflation is of great significance to avoid such complications [18].

International data suggest a 3.7% incidence of postoperative radial artery bleeding [19]. This datum includes not only bleeding after transradial artery puncture, but also after interventional therapy and the incidence may vary between countries and regions. The bleeding is closely related to insufficient compression time, inaccurate compression position, early activities of patients, and pain, which is directly related to the abundant distribution of nerves at the wrist. As patients can often see their own surgical site, the visual stimulus can bring psychological pressure to patients and cause neuropathic pain [19]. Overcompression can also lead to damage on the wrist, such as hematoma and bruising at the surgical site [20]. All of the above conditions are tied to the method of compression adopted after surgery.

In recent years, scholars have tried to reduce the occurrence of complications of radial artery puncture in various ways. Some believe that the distance of the radial artery puncture point is associated with complications after puncture [21]. For patients with small distal radial artery, weak pulsation, and tall body type, distal radial artery approach is not recommended. Others try to reduce complications by increasing or decreasing the dosage of clopidogrel and aspirin [22]. Besides, some studies try to reduce complications by adjusting the pressure intensity [23], but there is no research on the compression time. Therefore, this research compared continuous and intermittent deflation during compression and found that the intermittent deflation had more advantages in both the occurrence of complications and hemostatic effect. However, the incidence of bleeding and secondary hemostasis in group A was significantly higher than group B because a stepped gas release strategy was not implemented, bringing risks to patients and increasing the medical burden. This high incidence may be related to the agglutination process of platelets and coagulation time, which need to be further explored.

This research confirms the benefits of a 4-hour continuous deflation during compression, suggesting areas for further investigation, including the impact of compressor shape and material on hemostasis [24]. In addition, solely relying on the disappearance of radial artery fluctuation as an evaluation index may be insufficient for adjusting deflation [25, 26], and a comprehensive assessment may yield better results. The improvement of surgical methods may also be an important factor to reduce complications. Studies have confirmed the safety and reliability of distal transradial coronary interventional diagnosis and treatment, with advantages of better comfort and fewer postoperative complications, but the procedure is sophisticated and highly skill-required [27, 28]. Therefore, the innovation of surgical methods is also an important aspect. Other than that, limb placement, time of medication, adjustment of position, and activity of upper limbs after surgery may also have impact on the occurrence of complications [29].

Conclusion

This study provides a rigorous analysis of optimizing the mechanical pressure hemostasis program after transradial access, demonstrating that an intermittent deflation during 4-h postoperative compression can not only effectively achieve hemostasis but also reduce the complications of puncture. This study offers an evidence-based direction for clinical nurses to manage postoperative care for patients with radial artery access, paving the way for standardized postoperative nursing practices.

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Disclosure of conflict of interest

None.

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