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Invited Review

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Pneumatic Tourniquet for Surgical Procedures of Hemodialysis Vascular Access

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ABSTRACT

Pneumatic tourniquet has been frequently utilized in various surgical specialties to facilitate surgical procedures on the extremities. However, its use for surgical procedures of hemodialysis access has been limited to some surgeons in the United States and often confined to the hospital settings under general anesthesia or regional nerve block. We have successfully employed a pneumatic tourniquet system for surgical procedures of hemodialysis access under conscious sedation and local anesthesia in an outpatient setting. Because prolonged tourniquet inflation is associated with ischemic pain and other potential complications, we have limited the continuous inflation time to <30 minutes. Our recent data from 550 surgical procedures of hemodialysis access have emphasized that pneumatic tourniquet use is well tolerated under conscious sedation and not associated with significant adverse events. These and other reported data suggest that pneumatic tourniquet can reduce procedure time, minimize required dissection, reduce vascular trauma by eliminating vascular clamps and potentially improve the outcomes of surgical procedures of hemodialysis access. These advantages may be translated into cost savings for hemodialysis access care. This review discusses practical issues of pneumatic tourniquet use and its applications in surgical procedures of hemodialysis access.

Vascular access remains the Achilles heel for hemodialysis therapy. Because of their reduced complication rates and improved efficiency, arteriovenous fistulas and grafts are preferred hemodialysis accesses over catheters (1). However, the outcomes of their surgical creation are still quite variable and the optimal surgical techniques are still evolving. Additionally, surgical procedures are often required to maintain the functionality and to manage complications of these vascular accesses. Tools or surgical techniques that facilitate surgical procedures of hemodialysis access may potentially improve their outcomes (2).

Tourniquets are compressive devices that occlude venous and arterial blood flow to limbs. Their use dates back to ancient times and is tied to the history of amputations (3–6). Harvey Cushing has been credited to introduce pneumatic tourniquet in 1904 (3,7). Ever since, the pneumatic tourniquet has been frequently used for upper and lower limb surgery to reduce bleeding, improve visualization of important structures and expedite surgical procedures (7). However, tourniquet use has been associated with variety of complications, including serious complications that may threaten limb or life (3,4). During the past several decades, extensive studies regarding tourniquet use, safety, and its local and systemic effects have been conducted on both animal and human subjects (7–9). The modern pneumatic tourniquet was designed by James McEwan in the early 1980s and possesses automated safety features (Fig. 1) (10). Recently, the Association of perioperative Registered Nurses (AORN) and the Association of Surgical Technologists (AST) have published recommendations on safe use of pneumatic tourniquets (11, 12). When safety precautions are properly observed, modern pneumatic tourniquet is beneficial in promoting optimal surgical conditions and associated with a low rate of adverse events (5).

Pneumatic tourniquet use may simplify many surgical procedures of hemodialysis access, reduce blood loss, and minimize vascular injury that may potentially improve their clinical outcomes (13). Given these potential benefits, the routine use of pneumatic tourniquet for hemodialysis access surgeries may be worth exploring. Importantly, basic knowledge of proper tourniquet use is essential to avoid potential complications. This article reviews the basic concepts for safe tourniquet use and discusses tourniquet use for surgical procedures of hemodialysis access.

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FIG. 1. An automated pneumatic tourniquet system. The system consists of inflatable cuff, connection tubing, and pressure control device. The selection of tourniquet cuff (Panel A) is influenced by the size and shape of a patient's limb and the location of surgical site. Notice the contoured conical shape of the two larger cuffs. The standard cuff width is 14 cm for the upper arm (second right). The cuff is connected to the pressure control device via connection tubing (Panel B). The cuff is applied on the upper arm over a double-layered stretchable protective sleeve (stockinet) to avoid injury to the underlying skin (Panel C). Similar tourniquet systems are available from other manufacturers.

Pathophysiology and Potential Complications of Tourniquet Use

The pathophysiological changes of tourniquet application may be due to mechanical, ischemia-reperfusion, and systemic effects (7). Prior to tourniquet inflation, the limb should be exsanguinated using mechanical devices or limb elevation (5,7). This exsanguination results in autotransfusion of blood from the limb into the central circulation. There are numerous advantages of exsanguination, including establishing a clear operating field, reducing blood loss, and reducing the risk of microemboli at the time of tourniquet release (14). After tourniquet inflation, there is progressive cellular hypoxia, acidosis, and cooling of the occluded limb. Indeed, tissue injury may occur due to ischemia and local pressure (7). Muscle tissue is more susceptible to ischemic damage than nerve. Histological evidence of muscle damage is evident 30–60 minutes after tourniquet inflation (7, 8, 14). Tissue edema may develop and persist for weeks if the tourniquet time exceeds 60 minutes (7, 14). Pneumatic tourniquet application elicits both intravascular coagulation and fibrinolysis (15). After deflation of tourniquet, reperfusion injury may occur to the limb and produce various systemic effects if the tourniquet inflation is prolonged (7).

Tourniquet use may cause both local and systemic complications, which are usually associated with high cuff pressure and prolonged inflation (4, 5, 7, 8, 14). Local complications may include injuries to nerve, muscle, skin, and rarely, blood vessels (5, 7, 14). Skin chemical burn can be caused when solutions used for operative preparation passed underneath the tourniquet and remain there during tourniquet inflation (5, 16). Intraoperative bleeding or leak may occur due to an under-pressurized cuff, insufficient exsanguination, improper cuff selection, loosely applied cuff and calcified vessels (5, 14). The risk of deep venous thrombosis and pulmonary embolism is significantly increased with a tourniquet inflation time of more than 60 minutes (7). Pulmonary embolism has also been reported during limb exsanguination in patients with existing deep venous thrombosis (7, 14). A brief period of hypotension upon deflation, secondary to metabolic acidosis and hyperkalemia, can cause myocardial depression and even cardiac arrest in elderly or debilitated patients after prolonged lower limb surgery (7). Reperfusion injury can also affect the lungs, kidneys, and the central nervous system through systemic mediators or hemodynamic mechanisms (7, 14). These reperfusion effects can be attenuated with maneuvers such as passive leg raising (17), staggered tourniquet release (18), or other interventions (7, 14). More of historical importance, prolonged tourniquet inflation or forgotten tourniquet could threaten the limb or patient's life (3).

With modern tourniquet design and proper precautions, the incidence of clinically significant complications is reassuringly uncommon (5). For surgical procedures of hemodialysis access, we have limited the tourniquet inflation time to less than 30 minutes. In our experience with over 550 surgical procedures of hemodialysis access, no significant tourniquet-associated complication has been encountered (to be presented at 2014 ASDIN meeting).

Tourniquet pain develops in up to 66% patients, 30–60 minutes after tourniquet inflation (14). It can

be explained by ischemia, compression, and sensitization of the central nervous system (7). The pain tolerance in volunteer studies is approximately 20–30 minutes (5,7). Tourniquet-induced hypertension occurs in 11–66% of patients, the onset of which coincides with the onset of tourniquet pain (7, 14). General, regional, and local anesthesia, as well as systemic medications (such as magnesium (19) and sedation), can reduce and control the tourniquet pain (5, 7, 14).

Contraindications of Tourniquet Use

Several relative contraindications to the use of tourniquet have been described in the literature (Table 1) (7, 11, 12, 14). It is worth noting that these are relative contraindications. Although there are reports of increased complications rates in patients with sickle cell disease, uneventful use in such cases has also been reported (14). In patients with limb infection, tumor, deep vein thrombosis and fragile skin, alternative exsanguinations techniques may be used to minimize potential complications (7,20). Although diabetes mellitus has been listed as a contraindication by some (7, 11, 12), it is probably not warranted except in patients with significant arterial calcifications (5). Nevertheless, extra precaution in the perioperative period should be practiced in such patients (7, 14).

Recommendations for Safe Use of Pneumatic Tourniquet

Recommendations for safe use of pneumatic tourniquet have been published by AORN and AST (11, 12), and discussed by many authors in their reviews (Table 2) (4, 5, 7, 8, 14, 21). The primary consideration of these recommendations is patient safety. The incidence of adverse events can be consistently minimized if these recommendations are properly followed, thus enhancing the benefit-risk profile of tourniquet use (4, 5, 7, 8, 14).

Besides general assessments and precautions, clinical situations involving tourniquet use require at least three decisions: the shape and size of tourniquet, inflation pressure and continuous duration of inflation (5, 8, 14). The probability of tourniquet-related complications increases as the peak tissue pressure and tissue pressure gradient increases, thus it is desirable to achieve vascular occlusion with the lowest possible cuff pressure (5, 7). The shape of the tourniquet is critical to assure even tissue pressure distribution and effective arterial occlusion (5, 7). A contoured rather than a straight tourniquet should be used for conical shaped limbs to minimize excessive pressure at the proximal edge of the tourniquet (7). A wide or contoured tourniquet achieves hemostasis at lower inflation pressures than a narrow cuff and is painless when pressure is limited to the lowest effective level (5, 7). The widest cuff appropriate to the limb size (wider than half the limb's diameter) is preferred (7, 12). In spite of extensive studies in both animals and human, safe pressure and duration for tourniquet use remain controversial (8).

To minimize tourniquet-associated complications and pain, the tourniquet inflation pressure ideally should be individualized and minimum pressure should be used (5, 7, 11, 12, 14). AST recommends tourniquet inflation pressure 50 and 100 mmHg above systolic blood pressure for the upper and

TABLE 1. Relative contraindications of pneumatic tourniquet use

Severe atherosclerotic disease and presence of calcified vessels
Severe crush injuries
Severe brain injury
Sickle cell disease or sickle cell trait
Proven or suspected deep venous thrombosis
Tumor on the surgical limb
Abscess or other limb infections
Rheumatoid arthritis and other immune disease with vasculitis
Severe hypertension
Diabetes mellitus with calcified vessels
Poor cardiac reserve
Fragile skin and soft tissue
Other conditions that may affect its use

TABLE 2. Recommendations for safe use of pneumatic tourniquet

Preoperative assessment of patient's general health and limb condition essential
The tourniquet and accessories should be inspected and maintained regularly
Upper arm and mid/upper thigh are preferred sites of tourniquet application
Double-layered padding (stockinet preferred) should be used beneath the cuff
Avoid soaking of padding underneath the cuff with skin preparation solutions
The choice of tourniquet cuff size and shape needs to be individualized
Wider cuff is preferred, which can occlude arterial flow at lower pressure
Snug fit cuff application at both proximal and distal cuff edges to ensure even pressure distribution, with 3–6 inches of overlap
The limb should be exsanguinated before tourniquet inflation
Minimum tourniquet pressure should be used: 50 mmHg above SBP for arm, 100 mm Hg above SBP for leg (AST), or based on LOP (AORN)
Minimum inflation duration possible: arm <60 minute, leg <90 minute, 15 minute reperfusion internal if longer duration (AST and ACORN)
Patient should be continuously monitored while the cuff is inflated
Patient should be assessed postoperatively for any complications
Proper documentation of tourniquet use is required
The tourniquet and accessories should be cleaned after each use
Education and competency assessment of surgical staff are required
Policies and procedures for tourniquet use should be established

SBP, systolic blood pressure; LOP, limb occlusion pressure; AST, Association of Surgical Technologists; AORN, Association of periOperative Registered Nurses.

lower extremities, respectively (12). AORN recommends the tourniquet inflation pressures be based on limb occlusion pressure (LOP): 40 mmHg above LOP for LOP <130 mmHg, 60 mmHg above LOP for LOP 131–190, 80 mmHg above LOP for LOP >190 mmHg (11). Many practitioners use fixed tourniquet inflation pressures: 250 mmHg for the upper extremity and 300 mmHg for the lower extremity (8). These fixed pressures are usually significantly higher than pressures recommended based on LOP and systolic blood pressures, which is less optimal (5, 7, 14).

Limb occlusion pressure is the pressure at which arterial blood flow is occluded with a specific tourniquet over a specific limb (5, 7, 8, 14). LOP factors in the tourniquet width, limb girth and the blood pressures at a specific time. LOP is conventionally determined manually by inflating the tourniquet and recording the pressure at which the distal arterial pulsation ceases, usually verified by Doppler (5, 14). LOP can also be calculated using Graham's formula: LOP = [(systolic pressure–diastolic pressure) (limb circumference)/3(cuff width)] + diastolic pressure (7,22). A safety margin of 40–100 mmHg is added to the LOP or systolic blood pressure to take into the account of intraoperative blood pressure fluctuations (5,7,11,12). Studies have shown that the cuff pressure based on LOP measurement is lower than the commonly used cuff pressure and suggest lower risk of tourniquet-associated complications (5,7,11,12,14). Recently, a new tourniquet system with a design to synchronize the tourniquet cuff pressure to the patients' systolic blood pressure measured at 2.5 minutes intervals was reported (23). No tourniquet-associated complications were observed in 119 patients undergoing orthopedic surgeries using this system (23).

A safe duration of tourniquet use has not been established; consequently, it is important to minimize the tourniquet time to reduce the chance of complications (5). The duration of tourniquet use should ideally be less than 1 hour (7). If the required tourniquet duration is longer than 60 minutes for the upper extremity or 90 minutes for the lower extremity, a 15-minute reperfusion interval is recommended by AORN and AST. Based on current data, continuous tourniquet inflation time of 2 hours appears to be widely accepted safe limit (5,8,14) and the pathological impacts of tourniquet use remain reversible (8). Therefore, a reperfusion interval of 10 minutes after 2 hours of tourniquet inflation is suggested by some authors based on current data (8). To minimize duration of ischemia, tourniquet deflation prior to hemostasis and incision closure may be preferable (7). However, some studies showed no significant difference in complications like pain and ecchymosis when the tourniquet was released prior to and after skin closure. On the other hand, hemostasis was better and operative time was shorter if the tourniquet was released after skin closure (14).

Exsanguination Techniques Before Pneumatic Tourniquet Inflation

Before inflation of pneumatic tourniquet, exsanguination of the limb is commonly achieved by applying various tools, such as the elastic Esmarch bandage, the Pomidor roll-cuff or exsanguinators (5,7,20). While these tools are generally safe and effective, they may be associated with some disadvantages: having associated cost, posing potential risk of transmitting bacterial infections (24), being contraindicated in certain limb pathologies, causing potential tissue injury or even fatal pulmonary embolism (20). A recent article describes refinement of a century-old Bier technique, where the brachial artery is compressed in the cubital fossa before elevation of the arm and then the tourniquet is inflated (20). This method is simple, cost-effective, safe, and fomite-free (20). Supporting this approach, a recent study reports that tourniquet is better tolerated by healthy adult volunteers when exsanguination is achieved by limb elevation than by elastic bandage (average 24.1 minutes vs. 19.4 minutes) (25). However, studies using quantitative assessments indicate that exsanguination with brachial artery compression and limb elevation is not as effective as Esmarch bandage in reducing the blood volume of the upper limbs (26,27). Nevertheless, limb elevation with or without brachial artery compression may be especially useful for certain pathologies when direct mechanical compression of the limb may be contraindicated: limb infection, tumor, deep vein thrombosis, and fragile skin (7,20). To achieve maximum exsanguination by limb elevation without artery compression, it is recommended to elevate the arm at 90° for 5 minutes (28) and elevate the leg at 45° for 5 minutes (29) while the limb is sterilized and draped.

Reported Pneumatic Tourniquet Use for Surgical Procedures of Hemodialysis Access

Even though pneumatic tourniquet has been reported to assist surgical procedures of hemodialysis access for at least two decades (30), the extent of use in clinical practice is unclear. Ever since the description of pneumatic tourniquet use (i.e. "preventive hemostasis") to facilitate arteriovenous fistula creations in 1993 (30), Bourquelot has been a proponent of pneumatic tourniquet use for hemodialysis access surgeries (13,31–33). In the largest French series of 434 fistulas in 380 children using microsurgical techniques and pneumatic tourniquet, Bourquelot reported 78% being distal fistulas and 85% of the distal radial-cephalic fistulas were patent after 2 years (13), which was an outstanding outcome for children with small vessels. In a series of 171 fistula creations (167 in the forearm) in 132 patients, Pietu reported clinical success rate of 76% (34). Likewise, in a series of 90 fistula creations, Shemesh reported 1-year assisted primary patency

rate of 82% (2). Other reports of pneumatic tourniquet use for fistula creations had smaller sample sizes (33,35–37).

Pneumatic tourniquet has also been used for surgical procedures of hemodialysis access other than fistula creations – including aneurysm repair (38–40), lipectomy (32), and other access revision procedures (39). Pneumatic tourniquet use offers similar advantages for these procedures: reduced bleeding, procedure time, and trauma (39). Table 3 enumerates surgical procedures of hemodialysis access suitable for pneumatic tourniquet use at our surgery center. Figures 2–4 offer intraoperative photographs for some of the listed procedures.

TABLE 3. Surgical procedures of hemodialysis access assisted by pneumatic tourniquet

Surgical procedures of hemodialysis access	Number of cases (%)
Surgical procedures of autogenous hemodialysis access	
Arteriovenous fistula creation	377 (68.5)
Fistula aneurysm repair	105 (19.0)
Fistula reduction plus dilator-assisted banding (51)	4 (<1)
Fistula vein transposition	2 (<1)
Lipectomy or elevation for deep fistula vein	10 (1.8)
Arteriovenous fistula anastomosis revision	3 (<1)
Fistula surgical thrombectomy	4 (<1)
Fistula ligation or vein removal	5 (<1)
Surgical procedures of prosthetic hemodialysis access	
Placement of forearm arteriovenous graft	24 (4.4)
Graft pseudoaneurysm repair	8 (1.5)
Graft revision (i.e. bridge graft)	4 (<1)
Graft surgical thrombectomy	2 (<1)
Graft ligation or removal	2 (<1)
Total number of cases	550 (100)

Anesthesia Required for Pneumatic Tourniquet Use During Hemodialysis Access Surgery

Pneumatic tourniquet is often used under regional brachial plexus block (2,30,36,39) or general anesthesia (36). Regional brachial plexus nerve block offers the advantage of venodilation (2,13,41,42) that may result in a change of surgical plan for some patients (41). However, whether this transient venodilation significantly improves the clinical outcome of arteriovenous fistula creations remains to be established (42). Although

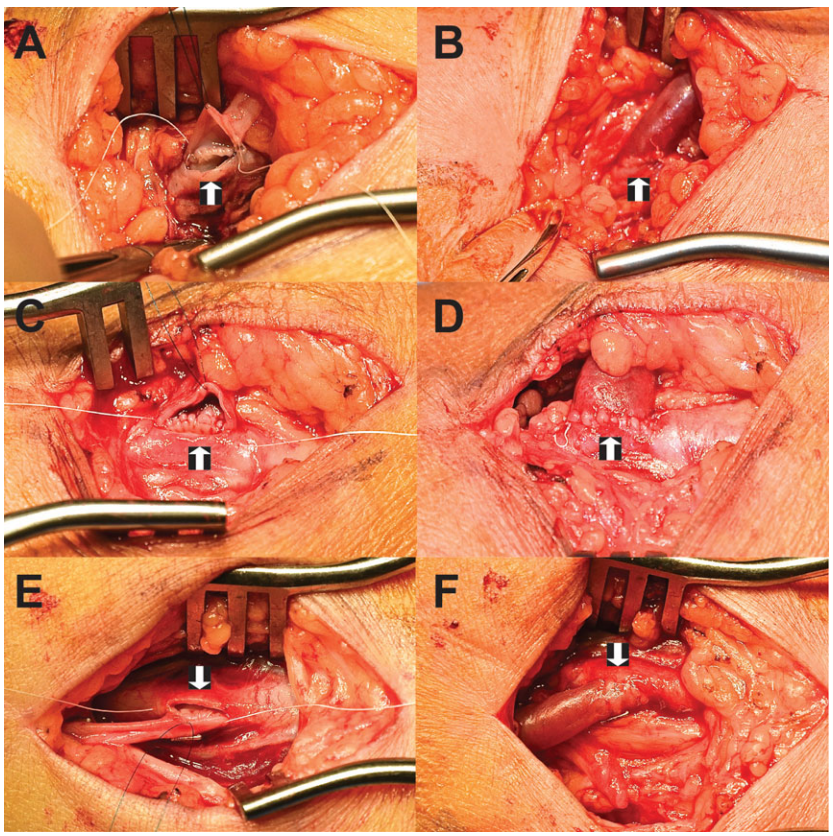

FIG. 2. Arteriovenous fistula creation assisted by pneumatic tourniquet. Both forearm and upper arm arteriovenous fistula creations may be performed with the assistance of pneumatic tourniquet. Shown are intraoperative photographs of fistula creations on a forearm (radiocephalic: Panel A – during anastomosis, Panel B – with finished anastomosis) and upper arms (brachiocephalic: Panel C – during anastomosis, Panel D – with finished anastomosis; brachiobasilic: Panel E – during anastomosis, Panel F – with finished anastomosis). Arrows indicate anastomoses. Note that no clamp is applied on the artery and vein during the procedure, and the dissection and trauma to vessels are therefore minimized.

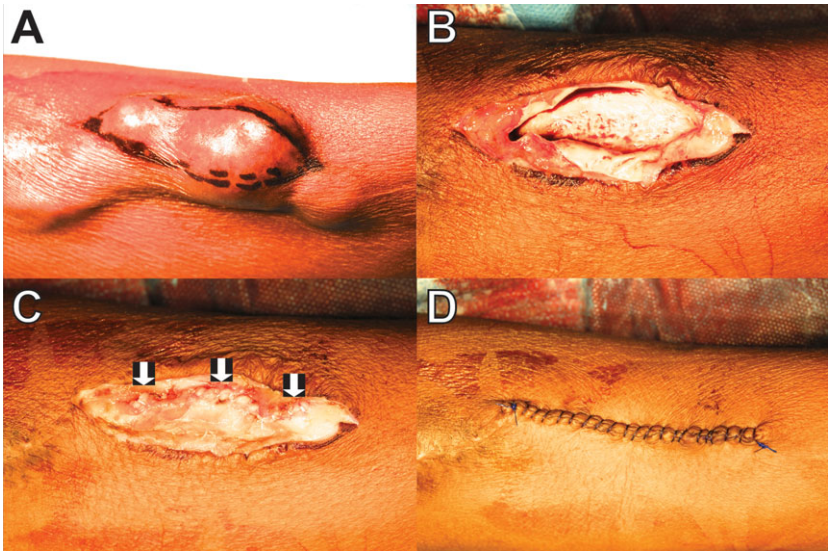

FIG. 3. Arteriovenous fistula aneurysm repair assisted by pneumatic tourniquet. The aneurysm of a forearm arteriovenous fistula has thin wall and is in danger of rupture with minimal trauma, and its repair is indicated (Panel A). The area of planned resection is indicated with marker. As hemostasis is achieved with the inflated tourniquet, there is no need for vascular clamps when the diseased aneurysm is resected (Panel B). The fistula vein wall is repaired with a continuous PTFE suture (Panel C, arrows) and the skin is closed with a prolene suture (Panel D). The use of tourniquet significantly simplifies the repair of the fistula aneurysm.

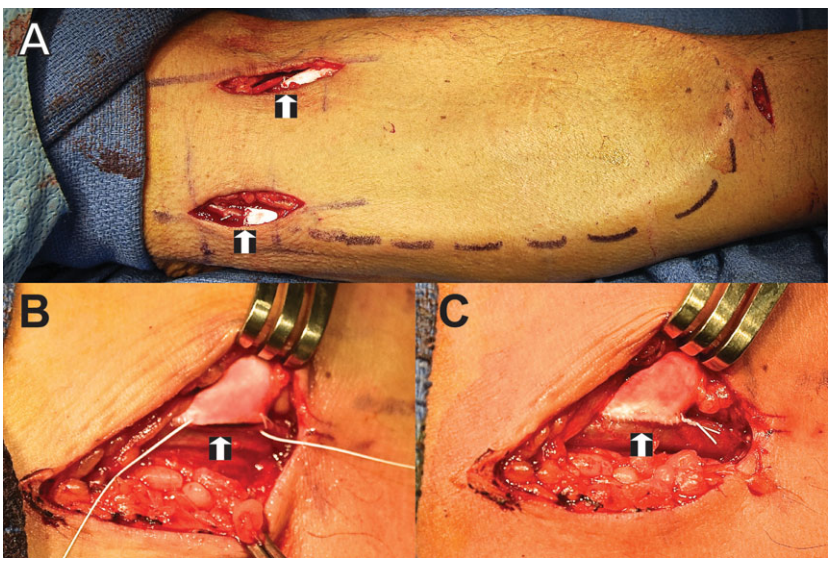

FIG. 4. Prosthetic arteriovenous graft placements assisted by pneumatic tourniquet. Forearm graft and lower upper arm short bridge graft placement may be assisted by pneumatic tourniquet. Shown are intraoperative photographs of graft placements on a forearm (Panel A, upper left is graft-brachial artery anastomosis and lower left is graft-basilic vein anastomosis) and lower upper arm (brachiocephalic: Panel B – during graft-vein anastomosis, Panel C – with finished anastomosis). This upper arm brachial artery-cephalic vein bridge graft is used to salvage a failed brachiocephalic arteriovenous fistula due to occluded distal cephalic vein. Arrows indicate anastomoses. Note that no clamp is applied on the artery and vein during the procedure, and the dissection and trauma of vessels are minimized.

regional nerve block and general anesthesia allow longer tourniquet inflation time, anesthesiologists, or specialized practitioners or special training are required. Conscious sedation plus local anesthesia was reported in 28 patients for whom tourniquet was inflated only during arterial anastomosis (36). In a report on arteriovenous fistula aneurysm repair from Iran, tourniquet was used under local anesthesia only (40). It was reasonably tolerated when the tourniquet inflation time was limited to less than 10–15 minutes (40). Based on our experience with over 550 surgical procedures of hemodialysis access performed in a freestanding outpatient surgery center, pneumatic tourniquet is well tolerated under conscious sedation plus local anesthesia when the inflation time is limited to

less than 30 minutes. The amounts of medications used for conscious sedation are less than those for similar surgeries performed without tourniquet (author's unpublished data). One advantage of conscious sedation is that nerve injury can be minimized as the patients are still able to respond to nerve stimuli during surgery. For patient comfort, we prefer that these surgical procedures be performed with conscious sedation in addition to local anesthesia.

Role of Anticoagulation During Surgical Procedures of Hemodialysis Access

No standard exists for the use of systemic heparin during surgical procedures of hemodialysis access to decrease the incidence of postoperative thrombotic complications (43). Similarly, there are limited reports evaluating the role of anticoagulation during these procedures. In two prospective, double-blinded, randomized controlled studies of 48 patients (43) and 50 patients (44) undergoing arteriovenous fistula creations, intraoperative intravenous heparin use did not significantly change the 4–6 week fistula patency rates (43, 44), but increased the incidence of bleeding complications (44).

There is no established role of anticoagulation during surgical procedures assisted with pneumatic tourniquet (7). In a double-blinded, randomized, controlled study, regional limb heparinization failed to reduce the embolic phenomena after pneumatic tourniquet release in total knee replacement patients (45). Among the reports related to pneumatic tourniquet use for surgical procedures of hemodialysis access, two described heparin use in their method section (2, 36), and the others did not mention heparin use (13, 33–35, 37). Because we routinely limit the tourniquet inflation time to <30 minutes for surgical procedures of hemodialysis access, we frequently do not use intraoperative heparin for these procedures and have not encountered clinically significant thromboembolic events. However, in patients with history of thrombogenic disorders or early fistula failure, intraoperative heparin may potentially be helpful.

Potential Advantages of Tourniquet Use for Hemodialysis Access Surgeries

There are advantages associated with pneumatic tourniquet use for surgical procedures of hemodialysis access based on the reports of other authors and our experience (Table 4) (30, 38, 39). The major advantages are: reduced vascular dissection and injury by eliminating vascular clamps, reduced procedure time and reduced bleeding. Importantly, these advantages may potentially translate into improved clinical outcomes. Although not proven by controlled clinical trials, current clinical reports and the author's unpublished data suggest that improved surgical outcomes are associated with tourniquet use for arteriovenous fistula creations (2, 13, 35, 37). Combined pneumatic tourniquet use with microsurgery is essential for fistula creations in patients with small vessels, especially in children (13, 34, 37).

TABLE 4. Potential advantages of tourniquet use for surgical procedures of hemodialysis access

Safe to use in outpatient settings
Significantly reduced operating time, therefore reduced cost
Reduced bleeding risk and blood loss
Improved visualization of anatomical details and reduced injury
Reduced skin incision and scar formation
Reduced vascular dissection and spasm
No need for vascular clamps, hence less vascular injury and future lesions
Making microsurgical fistula creation possible on children with small vessels
May obviate the need to discontinue oral anticoagulant therapy
Potentially improved outcome of access creation and revision procedures

Non-pneumatic Silicone Ring Tourniquet for Surgical Procedures of Hemodialysis Access

A non-pneumatic silicone ring tourniquet was introduced into clinical practice a few years ago for both upper and lower extremity surgeries (46). It is a sterile device that consists of a silicone ring wrapped within an elastic sleeve (stockinet) and two straps attached to pull handles. It can achieve both exsanguination and occlusion of arterial flow when the silicone ring is rolled up a limb, and the stockinet can provide sterile cover besides the operative field. The pressures exerted by the silicone ring vary with the silicone ring size and tension model (46). In comparative studies of silicone ring tourniquet and pneumatic tourniquet on unmedicated healthy volunteers, some authors reported similar pain scale and tolerance time (47), whereas others reported more pain with silicone ring tourniquet (48).

Silicone ring was recently reported being effective in generating bloodless operative fields in 27 patients for various surgical procedures of hemodialysis access (49). It offers some advantage for surgical procedures involving the upper arm, especially the proximal upper arm where pneumatic tourniquet application is cumbersome, if not impossible. However, the authors emphasized that adequate anesthesia (such as brachial plexus nerve block) was required as the silicone ring exerted pressure in a narrower zone than pneumatic tourniquet. Additionally, the authors also provided recommendations to avoid complications encountered (such as skin tear, postoperative hemorrhage, and vein twisting) (49).

Pneumatic Tourniquet for Surgical Procedures of Hemodialysis Access – Additional Considerations

Hypertension as a diagnosis is almost universally present in patients undergoing surgical procedures of hemodialysis access. The blood pressure is controlled in most of these patients and moderate hypertension typically does not require immediate intervention as the blood pressure tends to become lower in patients undergoing conscious sedation (50). However, a systolic blood pressure near or above 180–200 may need to be lowered with fast-acting medications before surgery to reduce the required tourniquet inflation pressure in our opinion.

We generally limit tourniquet inflation duration to <30 minutes, which is sufficient for fistula creation and most hemodialysis access revision procedures. In these cases, the tourniquet may be inflated before the start of skin incision. If the anticipated operative time is substantially longer, tourniquet inflation may be limited to vessel transection and anastomosis to keep its duration <30 minutes.

Tourniquet use in the presence of arterial calcification should be carried out judiciously. There are risks of failure to achieve arterial occlusion and arterial injury (5, 7). The use of LOP is likely to avoid excessive tourniquet pressure in such cases (5).

Obese patients often present a challenge to tourniquet application due to their excessive subcutaneous tissue. The efficacy of a wide and contoured tourniquet may be improved by having an assistant pull the skin and subcutaneous tissue distally before fastening the tourniquet (5). Alternatively, tourniquet may be applied to the forearm for distal forearm surgical procedures (5).

Intravenous prophylactic antibiotics should be administered 5–20 minutes before tourniquet inflation to allow adequate tissue perfusion of these agents (5, 7). However, antibiotic administration 10 minutes before tourniquet release appears to be as effective as before tourniquet inflation (7).

Conclusions

Pneumatic tourniquet may be utilized to simplify a variety of surgical procedures of hemodialysis access. It is safe when recommendations are properly followed. It is well tolerated under various anesthesia conditions, including conscious sedation and local anesthesia. It can reduce procedure time, minimize required dissection, reduce vascular trauma by eliminating vascular clamps and potentially improve the outcomes of these surgical procedures. These advantages may be translated into cost savings for hemodialysis access care. We suggest its routine use during surgical procedures of hemodialysis access in suitable patients.

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Conflict of interest

The author has no potential conflict of interests to disclose.

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None.

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