Torsion Does Not Affect Early Vein Graft Patency in the Rat Femoral Artery Model

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Torsion Does Not Affect Early Vein Graft Patency in the Rat Femoral Artery Model

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Abstract

Background
- Torsion of microvascular vein grafts (0.1 mm diameter) is a cited reason for graft failure in the clinical setting.
- Interposition vein graft torsion is a common technical error made by surgeons in microsurgery training courses.
- The objective of this study was to determine if torsion would lead to early vein graft failure in non-survival surgery rat models.

Methods
- 25 Sprague-Dawley rats were divided into 5 equal cohorts.
- Cohorts were labeled based on degree of vein graft torsion (0, 45, 90, 135, and 180 degrees).
- Torsion was created in the vein grafts at the arterial end by mismatching sutures placed proximal and distal to the anastomosis.
- Average vessel diameter was 1 mm.
- Vein graft patency was verified via methods 2 and 24 hours post-operation.

Results
- All vein grafts were patent 2 and 24 hours post-operation.
- Average blood flow rate measurements for 0, 45, 90, 135, and 180 degrees of torsion were 0.37 ± 0.02, 0.38 ± 0.04, 0.34 ± 0.01, 0.33 ± 0.01, and 0.29 ± 0.02 mL/min, respectively.
- Average blood flow rate measurements for 0, 45, 90, 135, and 180 degrees of torsion 24 hours post-operation were 0.94 ± 0.07, 1.03 ± 0.15, 1.10 ± 0.22, 1.45 ± 0.11, and 0.99 ± 0.15 mL/min, respectively.

Conclusion
- Torsion up to 180 degrees does not affect early vein graft patency in rat models.
- Suggestion to improve clinical reproducibility of practicing vein graft procedures in rat models.
- Microsurgery instructors should assess vein graft torsion prior to clamp release.

Methodology

Preparation
- 5 Sprague-Dawley rats were divided into cohorts based on degree of vein graft torsion (0, 45, 90, 135, and 180 degrees).
- The mean weight of the rats was 454 g (range, 380-530 g).
- The rats were anesthetized with a combination of ketamine (50 mg/kg) and xylazine (5 mg/kg), and anesthesia was maintained via an intraperitoneal ketamine bolus.
- All surgeries were completed using a surgical operating microscope (Zeiss OPMI MD; Carl Zeiss, Inc, Germany) and 3-0 nylon sutures with a 10-0 taper (Surgical Specialties Corporation, Reading, MA).
- Heparinized saline was used to irrigate the vessels throughout the procedure, and 1% lidocaine solution was applied to relieve any vascular spasm.

Preparing the artery
- An incision was created along the inguinal fold to expose the femoral vessels.
- The inguinal fat pad was dissected and the femoral artery was identified.
- All branches were ligated, cauteried, and transected.
- Single vascular clamps were applied to the femoral artery near the inguinal ligament (proximally) and the superficial epigastric branch (distally).
- A defect was created in the artery at the midpoint between the clamps, and the vessel ends were ligated with heparinized saline, trimmed for adventitia, and clamped.

Harvesting the vein graft
- Size mismatch between graft and recipient vessel ends is a cited risk factor for vascular thrombosis.
- To avoid this issue, the superficial epigastric vein was used for the graft as its diameter is similar to that of the femoral artery (approximately 1 mm in diameter).
- The epigastric vein was dissected, and 2 matching sutures were placed on the same linear segment on the vein's surface at a distance of 0.05 ± 0.01 mm from each other.
- The tail of the distal marking suture was left long to identify the distal end of the vein graft.
- 2 ligating sutures were placed.
- Near the superficial epigastric branch (proximally)
- Near the inguinal fat pad (distally)
- The vein graft was then harvested and ligated with heparinized saline, trimmed for adventitia, and clamped.
- All vein grafts were controlled to be 7.0 ± 0.5 mm in length.

Compiling the proximal anastomosis
- The anastomosis was completed with 3-0 interrupted sutures.
- Stay sutures were initially placed at the 12 and 6 o'clock positions.
- A third suture was placed at the 3 o'clock position, and the tail of its suture was left long as a handle to place the 3:30 and 4:30 suture clusters.
- The vessel was then rotated, and the sixth suture placed at the 9 o'clock position with its tail left long as a handle.
- The remaining sutures were then placed at the 3:30 and 4:30 o'clock positions to complete the anastomosis.

Twisting the vein graft at the distal arterial end
- Torsion was created in the vein grafts at the arterial end by mismatching sutures placed between the proximal end of the vein graft and the distal arterial end (Fig. 1).
- For example, to create 90 degrees of torsion, the suture placed at the 12 o'clock position on the proximal end of the vein graft would connect with the 9 o'clock position on the distal arterial end (Fig. 2).
- The vessel suture placed connected the 6 o'clock position on the proximal end of the vein graft with the 3 o'clock position on the distal arterial end.
- The sutures twisted 90 degrees, and the torsion would be placed as described by Cadley to complete the anastomosis.

Verifying patency
- After completing the proximal and distal arterial anastomoses and removing the clamps, the ligating fast passed was placed over the vein graft for hemostasis for 2 minutes.
- Torsion was verified 24 hours post-operation via a technique that used time ultrasonic blood flow measurements and the empty vs. full test.
- Blood flow measurements: Flow probes were placed under the distal arterial end (Fig. 3), and measurements averaging blood flow rates over 0 on 24s were recorded (Fig. 4).
- Time elapse tests: A straight edge pointer/forceps were placed adjacent to the distal arterial end and used to occlude the vessel. While occluding the vessel, the heart rate further from the anastomosis was transduced diastolically along the vein to the risk of the artery, leaving a segment of empty artery between the two forceps. The forceps closer to the anastomosis were then released, allowing blood to refill the empty artery. The anastomosis was patent.

Refill Test
- The refill test was repeated twice for each vein graft.
- The refill test can be performed before releasing the clamps (Fig. 3) and by any evidence of tension dispersing to the arterial ends after releasing the clamps (Fig. 4).

Discussion & Conclusion

Torsion of up to 180 degrees does not affect early vein graft patency in rat models.

In human patients, it is common to minimize dissection to reduce tissue damage and the potential of scarring, yet for interposition vein graft exercises in rat models, the femoral artery is dissected, which significantly minimizes the artery.

Torsion becomes widely distributed along the graft and artery and is quite difficult to appreciate visually.

Torsion is a potential risk factor for vascular thrombosis in the clinical setting.

To improve the clinical reproducibility of practicing vein graft procedures in rat models, we suggest that instructors of microsurgery training courses assess the success of a completed vein graft not only on patency but also on the basis of any torsion in the vein graft prior to clamp release.

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