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

Created by: Maxwell Levi
Rowan University School of Osteopathic Medicine

Abstract

Background
- Torsion of microvascular vein grafts (1 mm diameter) is a commonly cited reason for graft failure in the clinical setting.
- Microvascular vein graft torsion is a common technical error made by the 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) (Fig. 1).
- Torsion was created in the vein grafts at the distal arterial end by mismatching sutures placed at the proximal end of the vein graft and the distal arterial end.
- Average vessel diameter was 1 mm
- Vein graft patency was then verified via two methods, 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 2 hours post-operation: 0.37 ± 0.02, 0.18 ± 0.03, 0.04 ± 0.01, 0.33 ± 0.01, and 0.29 ± 0.02 ml/min, respectively.
- No differences were noted in the vessel diameter.
- The objective of this study was to determine if torsion would lead to early vein graft failure in non-survival surgery rat models.
- Microsurgery instructors should assess vein graft torsion prior to clamp release

Introduction
- Vein grafts are used to bridge vessel gaps in situations where primary vessel repair would result in excessive tissue damage.
- Microsurgery training courses incorporated interpositional vein graft procedures, using femoral or epigastric veins as grafts, in their curricula to provide surgeons with clinically relevant models to practice these procedures in a controlled environment.
- At the Microsurgery Training and Research Laboratory of the Columbia University Irving Medical Center, it was found that torsion of the vein graft is a common technical error made by surgeons.
- The torsion was caused by misalignment of the proximal and distal anastomoses.
- Torsion of vein grafts is commonly cited as a reason for vascular thrombosis in medical literature and clinical case reports, yet there was no data to suggest whether vein graft torsion would lead to thrombosis in a rat model.
- This study aimed to determine if vein graft torsion was a risk factor for vascular thrombosis in non-survival surgery rat models.

Methodology

Preparation
- 5-sets of 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 650 g (range, 350-350 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 injection
- All surgeries were performed using a surgical operating microscope (Zeiss OPMI PLUS; Carl Zeiss, Inc., Columbus, Germany) and 10X magnification (Surgical Operating Corporation, Reading, PA).
- Impregnated 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.
- 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 dilated.

Harvesting the vein graft
- Size-mismatch between graft and recipient vessel end 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 the femoral artery was identified.
- All branches were ligated, clamped, and transected.
- The vein graft was left long as a handle.
- The vein graft was then harvested and ligated with heparinized saline, trimmed for adventitia, and dilated.
- All vein grafts were controlled to be 7.0 ± 0.5 mm in length.

Completing the proximal anastomosis
- The anastomosis was completed with 4 interrupted sutures.
- A third suture was placed at the 12 o'clock position, and the tail of its suture was left long as a handle to place the 3:00 and 9:00 clots.
- The vein was then rotated, and the sixth suture was placed at the 8 o'clock position with its tail left long as a handle.
- The remaining sutures were then placed at the 3:30 and 9:30 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 distal arterial end by mismatching sutures placed at 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 3 o'clock position on the distal arterial end (Fig. 2).
- The vein graft was twisted by rotating the vessel at the 6 o'clock position on the proximal end of the vein graft with the 9 o'clock position on the distal arterial end.
- The other 6 interrupted circumferential sutures would then be placed as described by Cooley to complete the anastomosis.

Verifying patency
- After completing both the proximal and distal arterial anastomoses and removing the clamps, the initial felt patch was placed over the vein graft for hemostasis for 2 minutes.
- Patency was verified 2 and 24 hours post-operation via Doppler exam and time ultrasound blood flow measurements and the empty and refill test.
- Average blood flow measurement rate (24 hours) for each group.
- Vessel patency and flow rates were calculated and compared among the different groups.

Results

All vein grafts were patent 2 and 24 hours post-operation.

Table 1. Average blood flow measurements (24 hours)

<table>
<thead>
<tr>
<th>Torsion (degrees)</th>
<th>Average blood flow rate (ml/min)</th>
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<tbody>
<tr>
<td>0</td>
<td>0.37 ± 0.02</td>
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<tr>
<td>45</td>
<td>0.18 ± 0.03</td>
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<tr>
<td>90</td>
<td>0.04 ± 0.01</td>
</tr>
<tr>
<td>135</td>
<td>0.33 ± 0.01</td>
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<tr>
<td>180</td>
<td>0.29 ± 0.02</td>
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Discussion & Conclusion

Torsion 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 interpositional vein graft exercises in rat models, the entire femoral artery is dissected, which significantly multivascular 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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Authors: Amna Harb, Maxwell Levi, Akio Kozato, Robert J. Strauch, MD

References