·专题笔谈·

开放获取

后交叉韧带重建术中腘动脉损伤诊疗失误与对策

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摘要：后交叉韧带重建手术存在着众多并发症的威胁，其中最为严重且对患者造成的伤害最大的是术中误伤腘动脉。一旦发生这种情况，如果不能及时诊断和治疗，就会产生灾难性的后果，对患者的生命健康带来不可逆的影响。因此，为了防止这种情况发生，有必要深入了解和研究其产生的原因和临床表现，以便在实际操作中能够做到早预防、早发现、早治疗。基于这样的背景，本文通过结合相关病例的分析，详细阐述后交叉韧带重建手术中误伤腘动脉的发生原因，以及这种并发症的临床表现特征，并进一步探讨相关的防范措施和对策，以期在未来的医疗实践中能够有效地减少或避免这一严重并发症。

关键词：后交叉韧带，重建，手术，腘动脉

中图分类号：R687 **文献标志码**：A **文章编号**：1005-8478（2025）12-1063-06

Pitfall and countermeasures in diagnosis and treatment of popliteal artery injury during posterior cruciate ligament reconstruction // *HUANG Chang-ming, ZHU Tian-hao, FU Yang-pan, ZHANG Ya-qing. Department of Orthopedics, PLA 73rd Group Army Hospital (Chenggong Hospital, Xiamen University), Xiamen 361003, Fujian, China*

Abstract: There are many complications in posterior cruciate ligament reconstruction surgery, among which the most serious and the most harmful is the accidental popliteal artery injury during the operation. Once this happens, if it is not diagnosed and treated in time, it will have disastrous consequences and bring irreversible impact on the life and health of the patient. Therefore, to prevent this from happening, it is necessary for us to deeply understand and study the causes and clinical manifestations of it, so as to achieve early prevention, early detection and early treatment in actual operation. Based on this background, this paper attempts to elaborate the causes of accidental popliteal artery injury during posterior cruciate ligament reconstruction surgery and the clinical characteristics of this complication by combining the analysis of relevant cases, and further explore relevant preventive measures and countermeasures, in order to effectively reduce or avoid this serious complication in future medical practice.

Key words: posterior cruciate ligament, reconstruction, surgery, popliteal artery

后交叉韧带（posterior cruciate ligament, PCL）断裂占所有急性膝关节韧带损伤的 1%~44%[1]。关节镜下 PCL 重建是最常见的治疗方法。PCL 重建最严重的并发症是腘动脉损伤，如未及时诊治，会造成严重的功能障碍，截肢甚至危及生命。1986 年，Small 在超过 37.5 万例膝关节镜检查中仅发现 12 例血管并发症（0.54%），其中仅有 9 例损伤涉及腘动脉[2, 3]。偶有病例报道关节镜下半月板切除术、半月板修复术和关节镜下滑膜切除术后腘动脉损伤[4, 5]。尽管腘动脉损伤发生率不高，但一旦发生，必将造成灾难性的后果[6~8]（图 1a）。因此，早期如何诊断、及时准确治疗，以及术中如何避免腘动脉损伤是处理 PCL 重建并发腘动脉损伤关键环节[9, 10]。

1 腘动脉损伤原因

1.1 创伤因素

PCL 损伤常非单一损伤，多伴有多韧带损伤、膝关节脱位。膝关节脱位多韧带损伤常伴有腘动脉损伤[11, 15]（图 1b）。Natsuhara 等[16]在研究期间发现的 8 050 例膝关节脱位肢体中，267 例伴有血管损伤，总发生率为 3.3%。男性血管损伤的风险高于女性，患者年龄 20~39 岁有更高的血管损伤风险。Green 等[17] 报告一组 245 例研究中，膝关节 KD IIIM 型脱位的血管损发生率为 32%。Medina 等[18]分析了 862 例膝关节脱位患者，其中 171 例发生血管损伤，发生率为 18%。其中 80%的血管损伤进行了修复，12%的血管损伤导致截肢。血管损伤发生率最高分别见于 ACL、PCL 和内侧副韧带损伤（KDIIIL 脱位）（32%）和后脱位（25%）。

DOI:10.20184/j.cnki.Issn1005-8478.11083A

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图 1. 患者男性，42 岁，膝关节韧带损伤合并腘窝血管神经损伤后遗症，左小腿肌肉挛缩，足下垂畸形。1a：前面观；1b：后面观。

Figure 1. A 42-year-old male suffered from knee ligament injury combined with popliteal vascular and nerve injury, presented left calf muscle contracture and foot drop deformity. 1a: Front view; 1b: Rear view.

1.2 手术操作因素

PCL 重建手术操作失误是造成膝后血管神经医源性损伤的重要原因，特别是 PCL 重建术中建立胫骨隧道时，打入导针与钻头扩孔时失误更易发生血管神经损伤[19]。Alentorn-Geli 等[20]经尸体测量发现胫骨隧道导针距离腘动脉距离平均仅 2.1 cm。同时在用刨削刀清理后纵膈时，容易误将后方血管吸住刨伤[21]。或用等离子射频清理后纵膈时，将腘动脉灼伤。在慢性膝关节损伤，尤其是后方关节囊粘连严重患者，更容易损伤后方腘动脉。PCL 重建采用 Inlay 技术时，如未很好地显露膝后方结构，易误伤后方血管束或在置入移植骨块时压伤血管束[22]。更有甚者在行前交叉韧带重建，清理前交叉韧带股骨残端与髁间窝后外侧壁，造成后方腘动脉损伤[23]。另外还有取半腱肌股薄肌腱时伤及膝内下动脉，创建前内侧入路时损伤膝降动脉，并发假性动脉瘤[24, 25]。

1.3 其他因素

其他因素包括潜在的动脉硬化、充气止血带的使用、手术操作刺激引起动脉痉挛。Hagan 等[26]报告使用气动止血带可能导致动脉粥样硬化斑块破裂和远端栓塞，或压迫肌肉与骨性结构之间的血管，从而导致股动脉或腘动脉闭塞。手术操作也会引起动脉内膜破裂，血栓形成，甚至动脉急性闭塞[27, 28]。

2 腘窝血管损伤表现分型与处理原则

根据 PCL 重建并发血管损伤主要表现，笔者将其分为以下 4 种类型：

2.1 腘动脉闭塞血栓型

Wu 等[29]报告 1 例 PCL 重建术后即出现腘动脉血栓（动脉造影确认），因侧支循环良好，暂予观察，12 h 后动脉搏动可触及，之后予静脉注射肝素 5 d，再改用口服香豆素 3 个月，复诊时恢复正常。并认为血栓的形成是由于手术过程中对血管的压迫和操作所致，或者是由于动脉壁痉挛所致。

笔者收治 1 例 PCL 损伤，伤后 3 d 出现迟发性腘动脉栓塞患者。术前查体：左膝关节明显肿胀，伸直位，关节后方可见紫色淤血斑，关节周围压痛，关节屈伸明显受限。浮髌试验阳性，胫骨后沉征、后抽屉试验阳性；左下肢末梢感觉及血运良好。X 线片示左膝未见明显异常。左膝关节 MRI 示 PCL 断裂，前交叉韧带损伤。左下肢血管彩超提示左侧股静脉、股动脉、腘动脉通畅。于入院后第 3 d 在硬膜外麻醉行膝关节镜下 PCL 重建术。术中未触摸到左下肢足背动脉及胫后动脉搏动，高度怀疑腘窝动脉栓塞。决定先行 PCL 重建术（图 2a），再行左腘窝动脉探查术。术中可见腘动脉内有一长 5 cm 的硬结，血管外膜明显挫伤。显微镜下探查，纵形切开外膜及血管壁，见腘动脉完全阻塞（图 2b）。切取同侧大隐静脉 5 cm，倒转大隐静脉显微镜下桥接动脉（图 2c），术后左足远端足背动脉、胫后动脉搏动良好[30]。

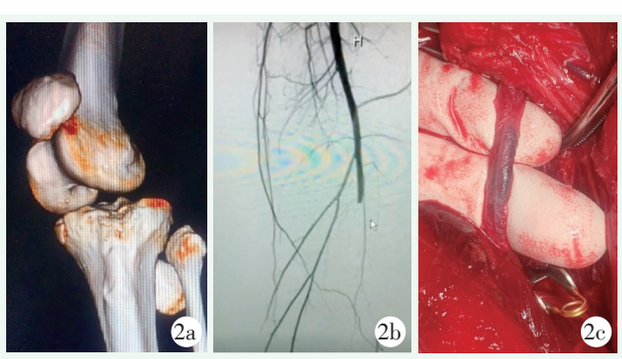

图 2. 患者男性，34 岁。2a：三维 CT 提示左膝关节脱位；2b：血管造影提示腘动脉损伤；2c：术中探查腘动脉损伤血栓形成。

Figure 2. A 34-year-old male. 2a: 3D CT indicated dislocation of left knee joint; 2b: Angiography indicated popliteal artery injury; 2c: Intraoperative gross view of popliteal artery injury with thrombosis.

2.2 腘动脉假性动脉瘤型

假性动脉瘤通常表现为疼痛的搏动性腘动脉肿块，而无肢体缺血的迹象，可以在手术后立即出现，

也可以在术后 4 年以上出现[31, 33]。其机理可能是血管壁不完全损伤，血液流入周围组织后被纤维包膜包裹，并且有血液湍流，表现为肿胀及搏动[34, 35]。也可表现为迟发性筋膜室综合征，与腘动脉假性动脉瘤增大破裂有关。尽管关节镜下 PCL 手术后可能会发生急性筋膜室综合征，但其原因为手术期间液体外溢到小腿后间室，这与假性动脉瘤增大破裂机理不同，临床表现也不同[36]。

2.3 腘动脉撕裂伤型

腘动脉撕裂伤型是 PCL 重建术中操作失误最常见的表现形式，常伴有神经损伤（图 3）。表现为手术完成后松开止血带，后内侧切口或入路大量出血，足背和胫后动脉均未扪及。下肢血管造影显示关节水平处腘动脉造影剂外溢。必须立即通过腘窝 S 形切口探查腘窝，修复腘动脉撕裂伤，常采用大隐静脉移植重建血管（图 4）[19]。

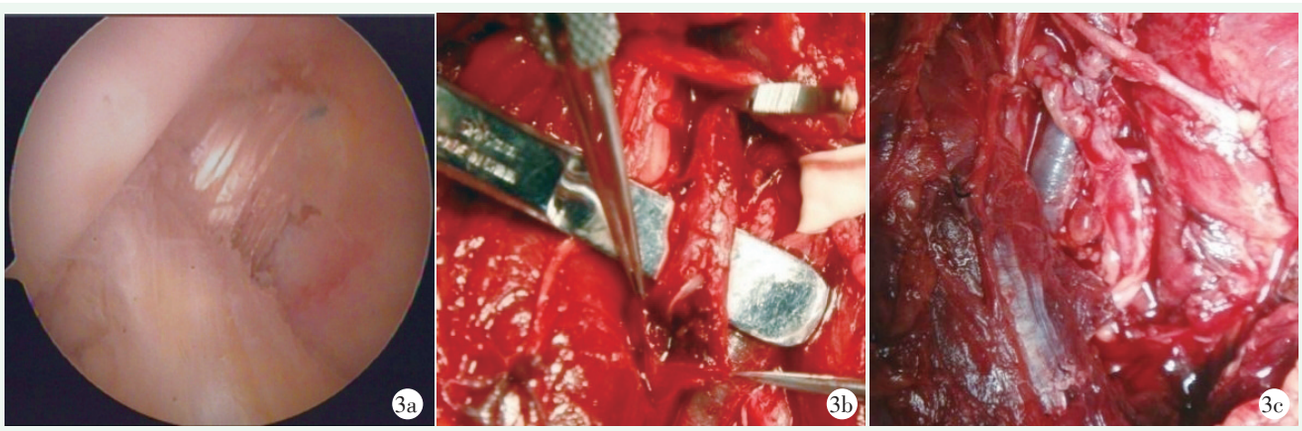

图 3. 患者男性，28 岁。3a：关节镜下见 PCL 重建良好；3b：腘动脉完全阻塞；3c：腘动脉血栓形成，行同侧大隐静脉桥接吻合术。

Figure 3. A 28-year-old male. 3a: Arthroscopic view revealed well reconstructed posterior cruciate ligament (PCL); 3b: Open exploration showed complete occlusion of the popliteal artery; 3c: Popliteal artery injurey was treated with contralateral great saphenous vein bypass anastomosis.

图 4. 患者男性，24 岁。4a：腘窝探查见腘动脉静脉、胫神经损伤；4b：术后缝合腘窝 S 形切口。

Figure 4. A 24-year-old male. 4a: Open exploration revealed injuries to popliteal artery and vein, tibial nerve; 4b: Postoperative appearance of S-shaped incision in the popliteal fossa.

2.4 腘动静脉瘘型

腘动静脉瘘型发生机理可能是 PCL 重建术中，如果导针的方向和深度出现偏差，同时造成腘动静脉的损伤，两者在血管鞘内，动静脉连接形成假通道，形成动静脉瘘。从临床表现看，因血管破裂损伤不严重，一般不会引起远端肢体血供障碍，仅出现下肢肿胀、疼痛等，血管彩超和下肢血管造影是早期确诊的关键[35]。

3 对 策

3.1 术前详细检查与评估

术前要详细评估下肢血管神经情况，特别是膝关节多韧带损伤或 PCL 损伤时，仔细观察下肢血循环和肌力，同时行彩超或 CTA 检查，以明确是否合并血管神经损伤，并排除是否患有动脉粥样硬化性疾病。

3.2 术中规范化操作，避免膝后血管神经伤

PCL 损伤重建术中，最易发生后方血管神经伤的操作为建立胫骨隧道过程。既往较多研究提出各种方法减少腘动脉损伤。Ahn 等[37]研究发现限制性后关节囊松解术可以增加腘动脉与 PCL、胫骨隧道距离，增加术中的安全性。Franciozi 等[38]则认为经胫骨结节外侧钻取 PCL 胫骨隧道较内侧更为安全。

如何避免损伤，在笔者看来，关键是导针打入后

方和钻取胫骨隧道时做到直视下操作，否则仅靠手感与经验易发生意外[39]。笔者采用膝关节屈曲 90°、五入路技术（前方三入路，即前内、经髌腱正中入路、前外入路；后方二入路，内后、外后入路），可充分显露后方纵膈、PCL 胫骨止点与后方相关结构，再用 PCL 瞄准器可以安全建立胫骨隧道（图 5b）。控制导针钻入深度，笔者研究发现，导针长度=瞄准器外套筒长度+13.5 cm（图 5c）。沿导针胫骨隧道时，导针尖端用双重保护技术，可避免钻头失手钻入后方血管神经束（图 6a, 6b）。上述措施，可以保残重建 PCL，同时避免建立胫骨隧道时发生后方血管神经伤（图 6c）。

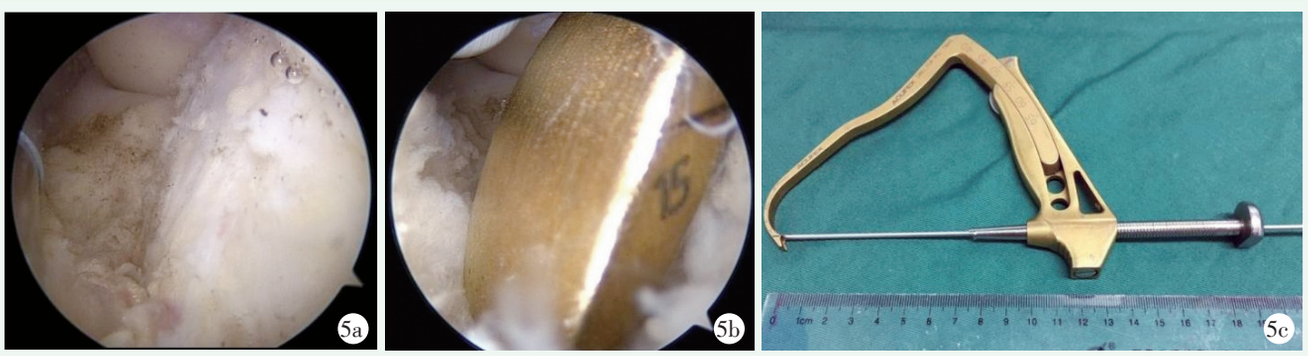

图 5. 患者男性，24 岁。5a：经后外入路观察，见 PCL 胫骨止点残端良好（右膝）；5b：经后外入路观察，安装 PCL 胫骨瞄准器（右膝）；5c：胫骨隧道打入导针长度=瞄准器外套筒长度+13.5 cm

Figure 5. A 24-year-old male. 5a: Arthroscopic view via the posterolateral portal showed the remnant of the posterior cruciate ligament (PCL) and intact tibial attachment (right knee); 5b: Arthroscopic view via posterolateral portal revealed the PCL guider placed (right knee); 5c: The length of the guide wire for femoral tunnel drilling = length of the outer sleeve of the aiming device plus 13.5 cm.

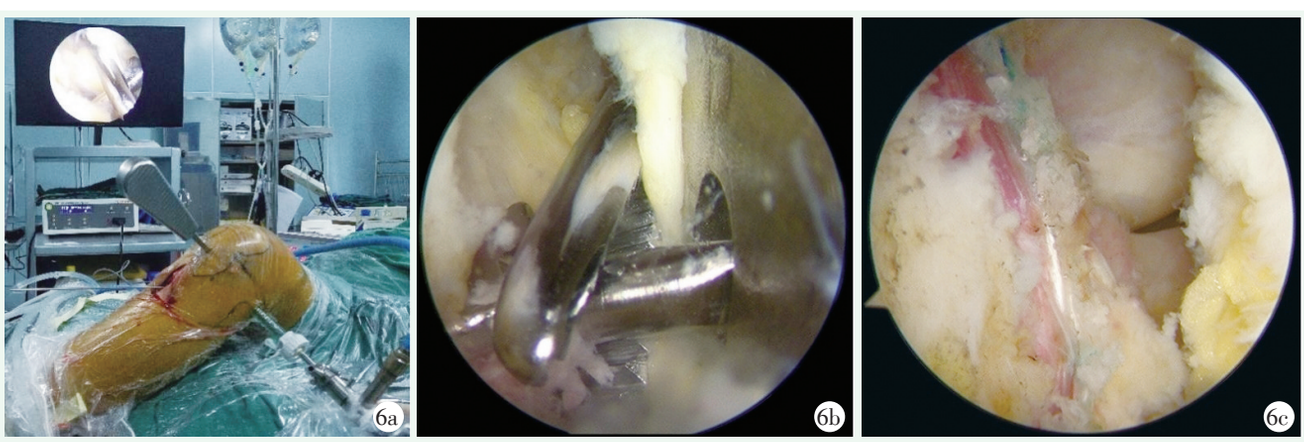

图 6. 患者男性，22 岁。6a：胫骨隧道导针尖端用 PCL 保护器与经后内入路保护体外（左膝）；6b：经胫骨隧道导针尖端用 PCL 保护器与经后内入路直钳夹住保护镜下（左膝）；6c：经后外入路观察，见重建 PCL 胫骨止点位置良好（左膝）。

Figure 6. A 22-year-old male. 6a: The tip of tibial tunnel guide pin was protected by the PCL protector via the posteromedial portal (left knee); 6b: Using a PCL protector over the tip of the tibial tunnel guide wire, and directly clamping under arthroscopic protection via the posteromedial portal (left knee); 6c: Arthroscopic view through the posterolateral portal showed the reconstructed PCL tibial insertion was in good position (left knee).

3.3 术后严密观察

术后要仔细观察下肢血运与感觉情况，如术中发生胫骨隧道建立失误，更应认真观察，果断及时行彩超或血管造影检查，明确诊断。一旦发生血管伤，应立即行探查、血管吻合术。最好在 6 h 内再通损伤，以减少肢体缺血产生的并发症与后遗症。

综上所述，尽管 PCL 重建或修复术中损伤发生率不高，但一旦发生，必将造成灾难性的后果。早期及时准确诊断、及时准确治疗，术中如何避免损伤是诊断与处理 PCL 重建修复并发血管损伤的关键环节。

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（收稿：2024-11-11 修回：2025-02-20）
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