

气压止血带在全膝关节置换术中应用的研究进展

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摘要

随着全膝关节置换术(total knee arthroplasty, TKA)的不断成熟, 术中如何使用气压止血带(简称止血带)已成为一个有争议的话题。使用止血带有几个好处, 包括改善术野、减少术中失血和缩短手术时间等。相反, 使用止血带也有几个明显的缺点, 包括术后疼痛、神经肌肉损伤、缺血再灌注损伤及血栓形成的风险增加等对患者康复有负面影响。因此包括麻醉医师在内的医疗团队应该对其应用有正确的认识。近年来关于止血带在TKA中应用的研究报道逐渐增多, 本文通过分析、总结止血带在TKA方面相关国内、外文献来对此做一综述。

关键词

气压止血带, 全膝关节置换术, 并发症, 肢体闭塞压力

Research Progress on the Application of Pneumatic Tourniquet in Total Knee Arthroplasty

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Abstract

With the continuous maturity of total knee arthroplasty (TKA), how to use pneumatic tourniquets (referred to as tourniquets) during surgery has become a controversial topic. The use of hemostasis has several benefits, including improving the surgical field, reducing intraoperative blood loss and shortening the operation time. On the contrary, the use of tourniquets also has several obvious disadvantages, including postoperative pain, neuromuscular damage, ischemia-reperfusion injury, and increased risk of thrombosis, which have negative effects on patient recovery. Therefore, the medical team including the anesthesiologist should have a correct understanding of its application. In recent years, research reports on the application of tourniquets in TKA have gradually increased. This article summarizes the domestic and foreign literature on tourniquets in TKA.

Keywords

Pneumatic Tourniquet, Total Knee Arthroplasty, Complications, Limb Occlusion Pressure

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1. 止血带类型

手动充气止血带是临床最早使用的止血带，它可通过压力显示器手动调节止血带压力，且其受压面积内肌肉受力均匀。但是手动充气止血带因放气时速度太快易致患者休克、使用时间较长后连接管容易漏气、压力指针容易不准、需要手动打气等缺点逐渐被临床淘汰。

电动气压止血带的出现，解决了手动充气止血带所有缺点，而且新增了漏气时自动补气到设定压力、自动计时、达到设定时间自动脉动式放气等优点，现在临床广泛使用。

O-Sung Lee [1]利用新材料制作的新型止血带，其原理：在手术部位的手指/脚趾上放置脉搏血氧饱和度传感器，袖带会自动充气至检测不出患者脉搏信号的压力，此压力为肢体闭塞压力(limb occlusion pressure, LOP)，根据 LOP 的值继续加压至合适的压力值时停止加压。用户也可以根据 LOP 设置安全阈值，临床医生还可以随时手动调节止血带压力。通过与传统充气式压力止血带进行 RCT 试验，认为新的止血带提供了更合适的无血外科手术束带，在 TKA 的止血带应用部位皮肤并发症发生率较传统止血带组低。这些优点使它成为需要止血带的 TKA 术中一种安全有效的医疗设备。

2. 止血带压力的设定

大量的临床实践告诉我们较高的充气压力可能会增加术后并发症发生的概率。我们理想的止血带压力设定的目标是：在提供无血的术野前提下，用较低的止血带压力以减少止血带相关并发症。我国对此还没有统一的标准，2009年美国围术期执业护士协会推荐的止血带充气压力[2]为：成年人肢体 LOP < 17.3 kPa (130 mmHg)者为 LOP + 5.3 kPa (40 mmHg)，LOP 17.3~25.3 kPa (130~190 mmHg)者为 LOP + 8.0 kPa (60 mmHg)，LOP > 25.3 kPa (190 mmHg)者为 LOP + 10.7 kPa (80 mmHg)。目前临床止血带压力的设定方案大致分为三类：传统经验法、参照收缩压制定法、个体化的充气压力法。

传统经验法是指各个医院按照既往经验设定的压力值,所有病人绝大多数是统一数值。参照收缩压制定法是指在下肢止血带压力的设定常规高于上肢收缩压 100 mmHg,至于到底高于上肢收缩压多少,目前也没有统一定论。Kim 等[3]的前瞻性随机对照试验研究认为,TKA 期间止血带充气压力高于收缩压 120 mmHg 是有效的方法。关于个体化的充气压力法,Lei Ding 等[4]认为通过收缩压和下肢围设定的压力是最小且效率最高的,也有研究者认为是根据实时的收缩压动态设定止血带压力值。近来也有将超声多普勒法应用在手术中设置下肢止血带压力[5],此方法在保证止血效果的同时,可以为患者提供最佳的个人止血带压力值。这样可以有效减少使用止血带不良反应的发生率,并提高止血带的安全性。综上所述,个体化的止血带压力在提供无血的手术视野和减少失血前提下,还可以降低止血带相关并发症。

3. 止血带应用时机

止血带在 TKA 术中应用时机,可以分为三种:全程使用、半程使用、骨水泥前后使用。全程使用是指切皮前到缝合包扎完全后;半程使用是指止血带在骨水泥完成后放气;骨水泥前后使用是指:仅在安装假体准备使用骨水泥至骨水泥干涸期间应用止血带。Huang 等[6]将这三组进行了 RCT 试验,结果显示:骨水泥前后使用组的血清炎症和肌肉损伤指标均较低,而膝关节评分(HSS)、估计失血量、肿胀率、VAS 疼痛评分和住院时间三者无显著差异。Wang 等[7]比较了骨水泥前后使用止血带与全程使用止血带,认为仅在骨水泥期间应用止血带可能会减少轻微并发症的发生率,并在 TKA 术后的早期康复阶段恢复较快的功能,但不能限制术中和全部失血。

Zhang Y. [8]也将 TKA 患者按止血带使用时机随机分为三组:全程使用、从手术开始至关节置换完成和从截骨术开始至关节置换。结果表明,最后一组患者止血带时间明显少于前两组($P < 0.05$),且患者住院期间止血带相关并发症发生率(6%)明显低于第一组(10%) ($P < 0.05$)。

4. 止血带能否减少出血

长期以来,一直提出临床使用止血带可以减少失血;但是,近年来研究报道止血带并发症越来越多,一些研究已经评估了在 TKA 期间使用和不使用止血带时出血情况,但结果尚有争议。我们在分析之前,对经常描述的各种失血形式进行区分。术中失血通常是通过海绵和纱布吸收的血液量加上手术期间吸出的血液来间接计算失血量的;术后失血通常是使用关节内引流或通过计算术后敷料吸收的血液量进行测量;隐性失血包括渗入组织的血液、关节中残留的血液以及溶血引起的失血。总失血量通常定义为术中、术后和隐性失血量之和。最后,用 Gross 公式来计算失血量,该公式将血红蛋白的变化作为确定失血的主要因素[9]。

在系统回顾中,Alcelik 等[10]评估了 10 个 RCT 试验,这些试验集中在 TKA 期间使用与不使用止血带相比,发现使用止血带时术中失血和总失血量明显减少。Smith 和 Hing [11]还针对相同的结果进行了系统回顾和荟萃分析,他们对 1040 个 TKA 病例进行了汇总分析,发现不使用止血带时术中出血量平均增加 269 毫升。止血带使用与否,术后和总失血的结果好坏参半。在 Smith 和 Hing 的先前研究[11]中,他们发现在整个医院疗程中总失血量没有显著差异,两组之间的输血需求也没有差异。

总之,在有和没有止血带的情况下,评估 TKA 失血的研究之间存在很大的异质性。

但是,目前的证据表明,使用止血带可能会减少术中出血,但是会增加术后失血和失血总量[12]。

5. 止血带在血管疾病及肥胖患者中的应用

人们对血管病患者 TKA 期间使用止血带有争议。有些研究证实在该患者人群中使用止血带的副作用很小。Walls 等[13]使用动脉双工超声检查发现,无论是否存在周围血管疾病,术后 6 周血流都没有明

显变化。Koehler 等[14]回顾性分析了 373 例已有血管钙化影像学证据的患者, 结果表明动脉钙化并不影响伤口愈合, 也不增加静脉血栓栓塞的风险。而另一些人担心内膜动脉钙化会与缺血性并发症(例如伤口愈合延迟和动脉血栓形成)相关, 且中膜动脉钙化会使动脉壁变硬, 可能导致失血增加[15]。Woelfle-Roos 等[16]研究结果显示, 在 TKA 中使用止血带后, 钙化的位置(内膜层与中膜层)确实会导致并发症。他们发现, 内膜钙化的轻微并发症(如伤口愈合延迟)风险为 6.1%, 而中膜钙化的并发症的风险仅为 1.9%。病例报告也显示, 血管钙化会降低使用止血带的有效性[17]。在先前作者的另一项研究中, 与没有钙化的同类队列比较, 在 350 mm Hg 止血带压力下, 动脉钙化患者比非钙化患者的术中失血量多[18]。

肥胖是骨关节炎发展和需要膝关节置换的明确危险因素[19] [20] [21] [22]。一些研究也同样表明, 肥胖是 TKA 术后并发症发生的危险因素[23] [24] [25]。关于最佳的止血带时间和压力以减轻这些并发症仍然存在许多问题。随着肥胖症患者率的增加, 每年行关节置换术的患者也越来越多。Gadinsk 等[26]发现止血带时长随着体重指数(BMI)的增加而增加。他们发现肥胖患者的止血带时间平均比非肥胖患者的止血带时间长 7.5 分钟。然而在类似的研究中, Lozano 等[27]未能显示出 BMI 组之间止血带时间的显著差异。他们还发现, BMI 组之间的总手术时间和住院时间没有显著差异。在另一项回顾性队列研究中, Li 团队[28]发现, 肥胖和非肥胖患者术后并发症没有差异, 包括贫血、深静脉血栓/肺栓塞、感染、假体松动、心脏病发作或中风。Lisa Croke 等[29]最新发表的《气动止血带安全指南》提出, 在使用止血带时对于体重指数较高的患者应谨慎[30]。目前, 尚无任何有助于确定肥胖患者最佳止血带时间和压力指南的 I 或 II 级研究, 而且还需要高质量的前瞻性研究来确定肥胖患者中使用止血带的术后并发症是否会增加。

6. 止血带相关常见并发症

血流动力学 使用止血带会影响心血管系统, 从止血带驱血开始到放气, ASA 等级越低的患者受血流动力学改变的影响越小, 但对心功能不全的患者可能有较大影响。在止血带驱血后会引发中心静脉压升高[31], 特别是止血带充气 30~60 分钟后, 舒张压、收缩压和心率增加, 并持续到止血带放气[32]。止血带放气期间监测患者生命体征至关重要, 放气会导致中心静脉压和动脉压迅速下降[32] [33], 短期低血压可能会导致心肌抑制和可能的心脏骤停[34] [35] [36], 这些血流动力学变化是由于血液容量回流到四肢, 以及四肢中积聚的代谢产物迅速进入体循环所致。

深静脉血栓(Deep vein thrombosis, DVT) 在使用止血带期间, 外科医生和麻醉医生都应实时关注的问题之一就是深静脉血栓(DVT), 这可能与肢体失血和止血带放气后引起患者血流动力学不稳定有关。据报道, 栓子的发生与止血带充气的时长之间存在重要的相关性[37]。患者在术中出现血流动力学波动可能引起深静脉血栓从而导致肺动脉栓塞的可能, 为此, 外科医生和麻醉医生应及时关注并进行治疗[31]。

代谢变化 肢体的挤压和缺血会引起代谢变化, 包括乳酸的堆积、 PaCO_2 和血钾水平的增加, 以及 PaO_2 和 PH 值水平的下降[32]。Ejaz 等[38]进行了一项前瞻性 RCT 试验, 该研究利用微透析技术测量了 TKA 期间体内骨骼肌的代谢变化。他们发现, 乳酸和甘油等缺血副产物的水平分别上升了 116% 和 190%, 而葡萄糖和丙酮酸等能量分别下降了 54% 和 60%。在一项类似的研究中, Rasmussen 等[39]使用微透析法测量止血带正下方的缺血性副产物的水平。与止血带远端的组织相比。他们发现, 止血带正下方的组织受到损坏的风险最大。然而, 这些缺血性损伤是可逆的, 通常在止血带放气后的 30 分钟内, 代谢变化就会逐渐逆转至正常[33]。

疼痛 据报道高达 66% 的患者在止血带充气大约 30~60 分钟后出现疼痛[33], 有研究称止血带部位有一种钝痛的感觉[32], 它在全身麻醉下更为常见(53%~67%), 并且最常见于下肢手术中[40], 表现为心率和平均动脉压增加。病理生理学尚未完全了解, 但据认为是由于皮肤神经机制引起的[41]。疼痛被认为是由无髓鞘的、缓慢传导的 C 纤维介导的, 通常被 A- δ 纤维抑制。约 30 分钟后, A- δ 纤维被机械压缩而

阻塞, C 纤维则继续起作用。止血带压迫导致受损细胞释放前列腺素, 这些前列腺素通过敏化和刺激疼痛受体来增加疼痛感。另外, 由于患肢反复输入伤害性感受性, 肢体缺血会通过 N-甲基-D-天冬氨酸受体激活而引起中枢敏化[42]。为了减少止血带疼痛对麻醉的影响, 已尝试了许多技术[43], 例如局部麻醉剂的渗透、使用较低充气压力的较宽袖带以及在脊髓阻滞剂中添加阿片类药物、可乐定、肾上腺素和局部麻醉剂等, 但没有一个在缓解疼痛方面取得完全成功。近来也有研究氯胺酮[44]、右美托咪定[45]、硫酸镁[46]、可乐定[47]、瑞芬太尼[48] [49]等静脉输注液的作用, 但是具体疗效还需更多临床试验去验证。

伤口愈合 Clarke 等[50]通过不使用止血带、低压(225 mmHg)止血带和高压(350 mmHg)止血带时测量伤口的氧气张力来评估止血带压力是否影响伤口愈合。他们发现, 所有三个组的氧气张力都有一定程度的降低; 但是, 与其他组相比, 高压组的张力明显降低。Heller 等[51]评估了伤口闭合前释放止血带是否对伤口并发症和皮肤起泡有影响。他们表明, 早期释放组的皮肤起泡发生率为 2.2%, 而止血带在闭合后释放时, 皮肤起泡的发生率为 7.5%。最后, Olivecrona 等人[52]评估了在止血带下是否应使用保护性屏障, 在比较了弹性止血带、石膏垫和止血带下没有保护材料三种情况, 并记录了手术结束时去除止血带时皮肤起泡的情况后, 他们发现弹性绒毛和填充衬垫可提供更好的皮肤保护, 并且皮肤损伤明显更少。

7. 研究展望

止血带在 TKA 中的使用可以给手术操作带来一定便利, 但是也会引起各种止血带相关并发症。我们提倡止血带的优化使用, 但是目前尚无大数据研究指导我们如何使用最优的止血带方案避免止血带相关并发症, 另外针对不同的手术类别、手术部位以及特殊病人缺乏一个有参考意义的指南来指导止血带的应用。

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