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磁压榨技术建立大鼠胃肠吻合模型的实验研究*

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摘要 目的:探讨采用磁压榨技术建立大鼠胃肠吻合模型的可行性。**方法:**设计加工适用于大鼠胃肠吻合的子、母磁体。将10只SD大鼠采用磁压榨技术进行胃肠吻合,子、母磁体分别经口置入大鼠胃和空肠内,子母磁体相吸压榨胃壁和肠壁,磁体间受压组织缺血坏死后连同磁体从吻合口脱落入肠道,胃肠吻合即建立,磁体最终经消化道自行排出体外,术后2周处死动物,获取吻合口标本,检测吻合口爆破压、肉眼和光镜下观察吻合口愈合情况。**结果:**10只SD大鼠中,1只因麻醉意外死亡,其余9只大鼠均顺利完成手术操作并存活至术后2周;手术平均操作时间(15.89± 3.25)min,磁体排出体外时间(8.56± 1.26)天(范围7-11)天;吻合口爆破压均大于200 mmHg,吻合口组织HE染色和Masson染色可见粘膜层连续性建立,愈合良好。**结论:**磁压榨技术可用于大鼠胃肠吻合模型制备,具有操作简单、成功率高的优点。

关键词:磁压榨技术;大鼠;胃肠吻合;动物模型
中图分类号:R-33;Q64;R656.6 **文献标识码:**A **文章编号:**1673-6273(2019)23-4429-05

An Experimental Study on the Establishment of a Rat Gastrointestinal Anastomotic Model by Magnetic Compression Technique*

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ABSTRACT Objective: To explore the feasibility of magnetic compression technique (MCT) in establishing a gastrointestinal anastomosis model in rats. **Methods:** Magnetic rings (parent and daughter) suitable for gastrointestinal anastomosis in rats were designed and processed. Ten SD rats underwent gastrointestinal anastomosis using magnetic compression technique. The parent and daughter magnetic rings were inserted into the stomach and jejunum respectively through the mouth. The parent and daughter magnetic rings were attracted to compress the stomach and intestinal wall. The magnets with ischemia and necrosis of the compressed tissue between them dropped from the anastomotic stoma to the intestinal tract. Then the gastrointestinal anastomosis was established. The magnets were eventually expelled through the digestive tract. Rats were killed two weeks after the operation. The blasting pressure was evaluated. The healing of anastomotic stoma was observed by naked eye and light microscope. **Results:** Except one SD rat died accidentally due to anesthesia, the other nine SD rats successfully completed the operation and survived two weeks after operation. The average operation time was (15.89± 3.25) min, and the expulsion time of magnetic rings was (8.56± 1.26) days (range 7-11 days). The bursting pressure of anastomotic stoma was more than 200 mmHg. The continuity of the mucosal layer was evaluated by HE staining and Masson staining, and the healing was good. **Conclusion:** The magnetic compression technique is a simple method of anastomosis that is feasible, fast and has high success rate for gastrointestinal anastomosis model in rats.

Key words: Magnetic compression technique; Rat; Gastrointestinal anastomosis; Animal model
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前言

胃肠旁路术治疗肥胖症和代谢性疾病越来越被重视，但其机制尚不十分清楚，因此仍然需要大量的动物实验来探究其治疗机制。SD 大鼠作为基本实验动物，具有模型稳定、成本低、饲养及管理简单等优点，广泛应用在肥胖和代谢性疾病的研究领域[1,2]。大鼠消化道管径小、管壁薄，对术者胃肠吻合的外科操作技术要求较高、学习曲线长、早期成功率低[3]。既往有采用支撑环加外捆绑的方法实现大鼠肠道无缝线吻合的研究[4]，但其操作仍较复杂，未广泛应用。

近年来，磁外科(magnetic surgery，MS)发展迅速，已形成以磁压榨技术(magnetic compression technique，MCT)、磁锚定技术(magnetic anchor technique，MAT)、磁悬浮技术(magnetic navigation technique，MNT)、磁悬浮技术(magnetic levitation technique，MLT)、磁示踪技术(magnetic tracer technique，MTT)为核心的临床应用技术体系[5]。磁压榨技术(MCT)在磁外科(MS)相关技术中起步最早、发展最成熟、临床应用最广。MCT 的研究或临床应用已涉及胃肠道吻合[6-8]、血管吻合[9-11]、胆道狭窄吻合[12-15]、胆肠吻合[16]、食管闭锁再通[17]、直肠阴道瘘修补[18-20]、血流阻断[21]、造瘘[22-24]、抗胃食管反流[25-28]、肛门闭锁开通[29]等方面，实验研究和临床应用结果提示优势凸显。前期，我们利用磁压榨技术成功实现了大鼠的小肠吻合和结肠吻合[30,31]。本研究通过设计特殊形状的磁体，提出利用磁压榨技术建立大鼠胃肠吻合模型的设想，并通过动物实验验证设想的可行性。

1 材料与方法

1.1 研究对象

10 只雄性 SD 大鼠体重 250-300 g，购于西安交通大学实验动物中心。该实验通过西安交通大学生物医学伦理委员会审批(审批号：XJTYLAC-2018-001)，整个实验过程符合实验动物伦理要求。

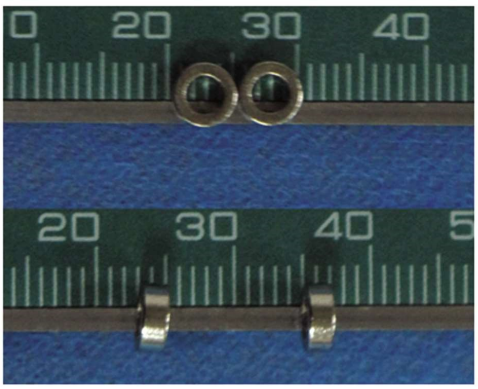

图 1 子、母磁体实物图

Fig.1 The daughter magnet and parent magnet

1.2 磁体设计

大鼠磁压榨胃肠吻合用的磁体包含子、母磁体两部分，子、母磁体均为外径 5 mm、内径 3 mm、厚度 2 mm 的环状结构，由 N45 钕铁硼永磁材料加工，表面镍镀层，沿厚度方向饱和充磁。磁体质量 0.18 g，表面场强 400-500 GS。子、母磁体实物见图 1。

1.3 手术设计

本实验为创新手术方式的可行性论证，因此不设对照组，10 只 SD 大鼠全部纳入实验组。磁压榨技术建立大鼠胃肠吻合模型的方法如图 2 所示。经口置入母磁体至胃内，然后人工辅助使母磁体经过幽门进入空肠；同法经口置入子磁体至胃内，调整子磁体和母磁体于合适位置并使其相互靠近，子母磁体对位吸合压榨胃壁和肠壁。当子母磁体间的胃壁和肠壁缺血坏死后，子母磁体连同磁体间的坏死组织一起从吻合口脱落进入吻合口远端肠管，最终经肠道自行排出体外。

1.4 手术操作及术后管理

所有大鼠术前禁食 12 小时，不禁饮，电子秤称量大鼠质量。3%戊巴比妥钠腹腔注射麻醉(0.1 mL/100 g)。麻醉满意后仰卧位固定于小动物手术台，常规消毒、铺巾，取上腹部正中切口，长约 4 cm。经口置入母磁体，5F 鞘管推送母磁体至胃内，然后棉签挤捏法推送母磁体缓慢通过幽门部，棉签继续推送磁体至 Treitz 韧带远端约 40 cm 处；同法经口置入子磁体至胃内，调整母磁体位于空肠对系膜侧，上提空肠使空肠内母磁体与胃内子磁体对位吸合，检查肠管无扭转后，4-0 丝线逐层、间断缝合关腹。

术后立即行腹部正侧位 X 线片，观察磁体位置，明确磁体是否对位良好。大鼠置于保温箱内，待麻醉苏醒后放回大鼠饲养盒内，自由摄食、摄水。术后 48 小时内每间隔 12 小时给予肌注盐酸哌替啶 0.5 mg/100 g 镇痛。术后注意收集大鼠排出的磁体，并记录排出体外时间。

1.5 标本获取

术后 1 月，戊巴比妥钠腹腔注射麻醉后开腹，放血法处死大鼠，获取吻合口标本(标本包括食管下段、全胃及十二指肠、空肠吻合口远端 5cm)。浸水注气法检测吻合口爆破压；纵向剖开吻合口肉眼观察胃肠吻合口愈合状况；修剪吻合口组织，10%福尔马林固定，石蜡包埋并切片，HE、Masson 染色，光镜下观察吻合口组织愈合情况。

2 结果

10 只大鼠除 1 只因麻醉过量导致死亡外，其余 9 只大鼠均成功实施手术，并且术后存活良好。术中胃肠吻合及术后 X 线检查结果见图 3。9 只大鼠平均手术时间为(15.89± 3.25)min，磁体排出时间为(8.56± 1.26)天(7-11 天)。浸水注气法检测胃肠吻合口爆破压均大于 200 mmHg。肉眼观察可见胃肠吻合口黏膜光滑平整，愈合良好，吻合通畅性良好，图 4。光镜观察可见吻合口黏膜层连续性好，各层愈合良好，见图 5。

3 讨论

胃肠吻合术是普通外科基本操作之一，管状吻合器与传统手工缝线吻合相比可显著简化操作难度、缩短操作时间，临床应用广泛，已逐步取代手工缝线胃肠吻合。大鼠胃肠吻合对于初学者而言，学习曲线长，早期吻合成功率低，而目前尚无用于大鼠胃肠吻合的成熟装置。磁压榨吻合作为一种无缝线吻合模式，在空腔脏器吻合重建方面有巨大优势。基于既往研究积累，本研究将磁压榨技术引入到大鼠胃肠吻合中，研究结果显示具有巨大优势。

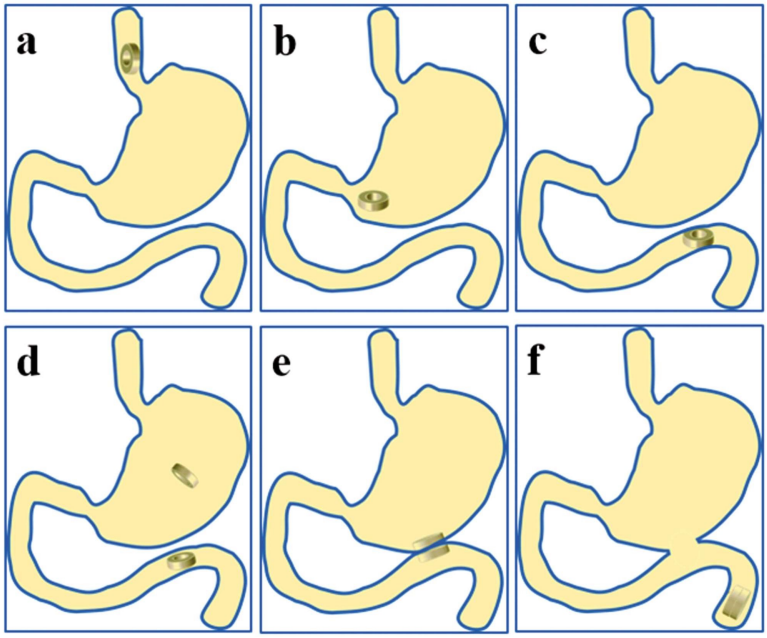

图 2 磁压榨大鼠胃肠吻合操作示意图

Fig.2 Schematic diagram of gastrointestinal anastomosis in rats under magnetic compression

注:a.经口置入母磁体;b.母磁体进入胃内;c. 母磁体进入空肠内;d.经口置入子磁体至胃内;e. 子母磁体自动对位吸合压榨胃壁和肠壁;f.吻合建立后子母磁体脱落进入远端空肠

Note: a. Put into the parent magnet through the mouth; b. The parent magnet enters the stomach; c. The parent magnet entered the jejunum; d. Put the daughter magnet into the stomach through the mouth; e. The daughter magnet and the parent magnet automatically attract and compressed the gastric and intestinal walls; f. After the anastomosis was established, the daughter and mother magnets fell off into the distal jejunum.

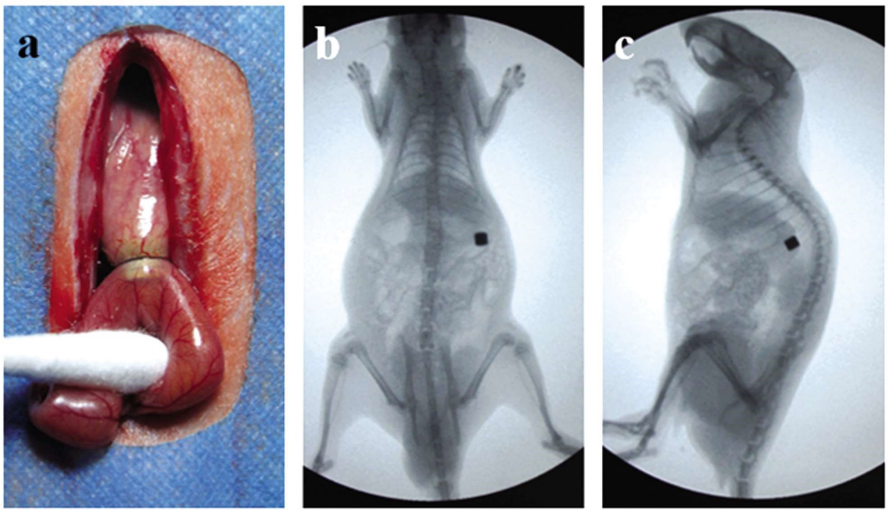

图 3 术中及术后 X 线检查

Fig.3 Intraoperative and postoperative X-ray examination

注:a.术中子母磁体吸合后的状态;b.术后腹部正位片;c.术后腹部侧位片

Note: a. The state after the daughter and parent magnets attracted during the operation; b. The anteroposterior view of fluoroscopy after operation; c. The lateral view of fluoroscopy after operation.

本研究中,子、母均为圆环状设计,其外径与大鼠肠道内径相当,圆环状的设计方便磁体经口置入,利用鞘管推动法可将磁体推送至胃内,棉签挤捏法可使磁体很容易通常幽门。该设计具有两大优点:第一,经口置入法可避免术中打开胃腔和肠腔,大大精简了手术操作过程,并且能够有效降低并发症发生率,这也是其他吻合方法所不具备的独特优势;第二,在确保足够的吻合口大小的情况下,可尽可能减小磁体横截面积,利于磁体通过食管和幽门等狭窄部位。本实验采用磁体完成的是胃和空肠的侧侧吻合,其缺点是磁体置入后早期不能建议胃肠旁路通道,需等到术后 7-11 天待子、母磁体脱入肠道后胃肠旁路通道才能建立,这是其局限性,因此利用该方法建立大鼠胃肠吻合模型时必须结合具体的实验设计和实验目的。

钕铁硼磁体具有优良的磁学性能,高磁能积、高剩磁、高矫顽力,被誉为 " 磁王 ",且价格便宜、易加工、组织相容性好,是

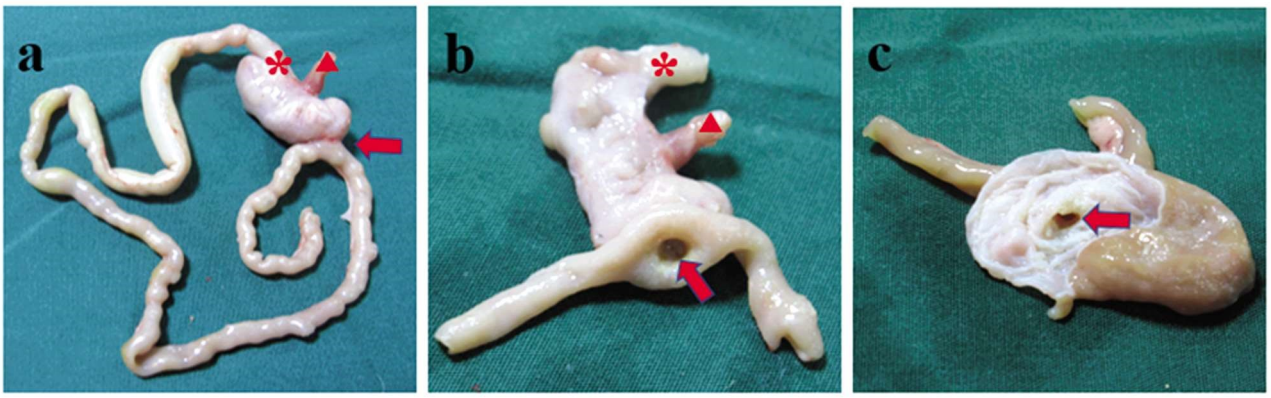

图 4 吻合口大体标本

Fig.4 Anastomotic gross specimen

注:a.术后 2 周吻合口大体标本;b.空肠侧所见吻合口;c.胃侧所见吻合口(* 为幽门、△ 为食管、→为胃肠吻合口)

Note: a. The gross specimens of anastomosis 2 weeks after operation; b. Anastomosis observed on the side of the jejunum; c. Anastomosis observed on the side of the stomach (* pylorus, △ oesophagus, → gastrointestinal anastomosis).

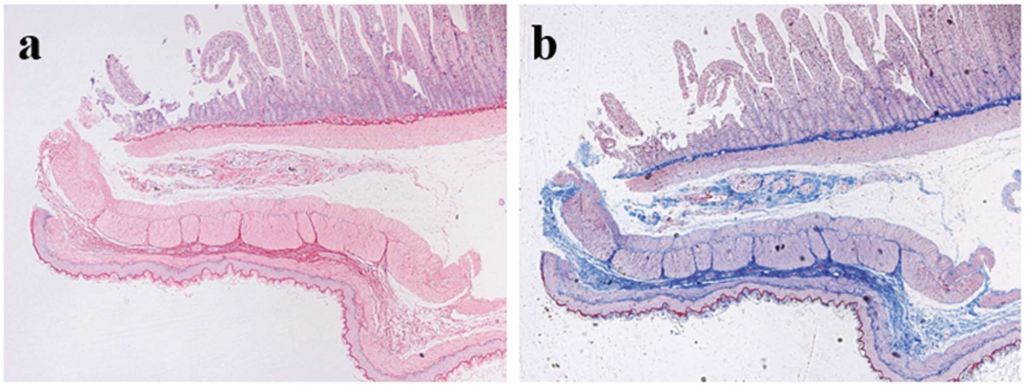

图 5 吻合口标本光镜下观察

Fig.5 Observation of anastomotic specimen under light microscope

注: a. HE 染色 (40);b. Masson 染色 (40)

Note: a. HE stain (40); b. Masson stain (40)

磁外科领域最常用的永磁材料。本研究中,子、母磁体均以钕铁硼为原材料,可以提供足够的压榨吻合力。钕铁硼磁体缺点是抗氧化能力差、易腐蚀,尤其是在复杂的消化道环境中更易被腐蚀[32]。镍 - 氮化钛复合镀层的钕铁硼具有良好的抗胃液腐蚀能力,但其表面改性工艺较复杂,成本高。本研究显示磁体排出体外的平均时间为 8.56 天。我们前期进行的磁体抗胃液腐蚀实验显示镍镀层在短期内不会出现严重腐蚀和磁体崩解[33],完全能够满足动物实验需要。当然,过量的金属镍离子释放对机体有一定的害处。因此,在临床使用时,建议使用氮化钛镀层或高分子材料复合镀层为佳。

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