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ANALYSIS OF STUDIES ON MAGNETIC COMPRESSION ANASTOMOSIS

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Abstract
This article explores the key data on the new method of MCA (magnetic compression anastomosis). This topic is both interesting and relevant, as the method has not yet been included in official clinical guidelines (protocols) of most countries, including international standards such as NCCN, ESCP, ASCRS, WSES, etc. However, the situation is evolving, and every quarter new scientific research articles are published worldwide, describing the effectiveness of this surgical technique. Our analysis aims to identify the main reasons why this method has not yet gained wide adoption in pediatric surgery, despite its effectiveness, accessibility, and applicability in a considerable variety of surgical diseases in children under 17 years of age. Literature searches in Chinese and English were conducted in leading scientific databases, from which 20 of the most relevant publications were selected for analysis. Based on this analysis, two main reasons were identified for why MCA is not yet included in clinical protocols: (1) MCA remains insufficiently studied due to the limited number of large-scale clinical trials — most publications are case reports or small case series; (2) there is a lack of reliable data on the long-term effectiveness and safety of the method.

Keywords: Magnetic compression anastomosis, magnetic compression, esophageal atresia, colostomy, minimally invasive colorectal surgery, pediatric surgery.

Introduction

Minimally invasive pediatric surgery has significantly developed over the past three decades, along with all other branches of medicine. During this time, we can recall the invention and implementation of various new surgical methods and innovations, such as natural orifice transluminal endoscopic surgery (NOTES), single-use laparoscopic and thoracoscopic surgery, robotic systems like DaVinci and Senhance, diode or Nd:YAG lasers used in selective fetoscopic laser photocoagulation in fetal surgery, and many others (1). However, some of these innovative methods have still not been incorporated into global treatment standards and protocols. Our focus will be on a new and effective method in minimally invasive surgery: magnetic compression anastomosis (MCA).

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Objective of the review

This analysis is conducted with the aim of understanding the main reasons why MCA has not yet been incorporated into global treatment standards. The purpose of this article is to answer key questions such as: What exactly is MCA? This is for readers who may not yet be familiar with the method. In which fields of medicine can the method be useful? What are the capabilities and limitations of MCA? Most importantly, to identify possible shortcomings that hinder the adoption and widespread use of this method in clinical practice.

Materials and Methods

Since the first research articles on this topic were conducted in China and published in Chinese scientific journals, but a significant portion of the research results, especially the more important and internationally relevant ones, were also published in English, my literature search was conducted in both languages. The search was performed in recognized scientific databases such as CNKI, Wanfang, YIIGLE, PubMed, SpringerLink, MDPI, SAGE, ScienceDirect, and Liebert. Among many publications, 20 of the most relevant articles were selected for analysis.

Analysis and Discussion

Magnetic compression technology (MCT) is based on the use of magnetic attraction force between two or more magnets or between magnets and paramagnetic materials to perform organ repositioning, compression, and tight tissue sealing. This technique is applied in open (including thoracic), laparoscopic, endoscopic, and interventional surgical procedures for the diagnosis and treatment of various diseases. In MCT, magnets positioned on both sides of the compression zone are classified as parent and daughter magnets. The parent magnet (PM) typically has a larger volume, a fixed position, and an active pulling effect during compression. The daughter magnet (DM), conversely, is smaller, less stable in position, and passively drawn into the magnetic field. Pathomorphological changes at the anastomosis site include ischemia, necrosis, and subsequent rejection of the compressed tissues, while adjacent structures undergo stages of adhesion formation, regeneration, and healing. Due to the "contactless" nature of the magnetic field, MCT enables sutureless anastomosis formation without invasive penetration into the tissues (2).

Applications of this method include esophageal atresia – connecting the ends in congenital obstruction, esophageal strictures – eliminating post-burn or postoperative narrowing, anorectal malformations – forming the anal canal in congenital anomalies, urethral strictures – restoring urethral patency, ileostomy and colostomy – closing temporary stomas without reoperation, and ureterocystoanastomosis – connecting the ureter to the bladder in cases of impaired urinary flow (3–7).

In a retrospective analysis of preclinical and clinical studies by Oliver J. Münsterer involving 250 MCA procedures on animal models (dogs and rabbits), including gastrointestinal and urinary tracts, and 87 MCA procedures in 86 children aged 2 to 10 years, the overall success rate was 87%. The types of clinical interventions included nonoperative esophageal recanalization (n = 15), nonoperative ileostomy without diversion (n = 46), Swenson pull-through (n = 10), nonoperative urethral recanalization (n = 5), and extravesical ureterocystoneostomy (n = 11) (7). Some limitations of the MCA method were noted, such as weak magnetic compression leading to

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anastomotic failure and excessive tissue scarring. This is especially relevant when there is excessive distance between magnets or interposition of bulky tissues. Based on these considerations, recommendations were given for application, emphasizing careful selection of magnetic compression force depending on tissue thickness and condition to ensure reliable connection without excessive pressure.

Researchers Shi-Ci Liu and Qi-Feng Li described a successful case of MCA use in a premature girl (30+6 weeks, weight 1660 g) with rectal atresia after necrotizing enterocolitis. They designed and manufactured two ring magnets (diameter 12 mm, attraction force ~2500 Gauss): the “parent” ring in the cecum and the “daughter” ring in the distal rectum. Under balloon catheter control, the magnets were approximated to form a magnetic compression anastomosis between the blind ends of the bowel. Clinical observation showed that the magnets were expelled spontaneously on day 9, with no perforations or early complications; after 3- and 7-month follow-ups, an anatomically and functionally complete anastomosis without strictures was observed (8).

From their successful case report, it became clear that the method has some limitations that may reduce treatment efficacy. Weak magnetic compression can lead to anastomotic failure and excessive tissue scarring, particularly when there is an excessive distance between magnets or bulky tissue interposition. Excessive compression in areas with pronounced scarring can cause perforation, especially if the tissues have insufficient healing capacity. The use of flat magnets is associated with a higher risk of scar and stricture formation, potentially narrowing the anastomotic lumen. Recommendations indicate that magnetic compression force should be carefully selected based on tissue thickness and condition to ensure a secure connection without excessive pressure. Preference should be given to magnets with rounded edges, which provide even pressure distribution and reduce the risk of strictures. It is important to consider tissue healing and regeneration processes when planning MCA use, especially in pediatric practice.

However, the opinions of interventional radiologists should also be considered. Magnets placed at the obstruction site must be properly oriented before placement; thus, attraction points should be determined ex vivo before pushing the magnets together. If the magnets face each other with opposite poles, they will repel. In this case, a guiding catheter with an angled tip can be used to rotate and/or reposition the magnets. Finally, in cases of extravasation and loss of integrity of the biliary ducts, ureters, or intestinal tracts, the procedure should be postponed to prevent the magnet from falling into the abdominal cavity (9,10).

Conclusion

From the analysis of the aforementioned scientific studies, we can identify several main reasons why MCA has not yet been included in treatment protocols, global standards, and has not gained widespread adoption worldwide. First, most publications on MCA consist of isolated clinical cases or small case series. The lack of large randomized controlled trials complicates the assessment of the method’s efficacy and safety compared to traditional surgical approaches. Second, the long-term outcomes and safety of the method remain insufficiently defined.

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