13 Transanal Minimally Invasive Surgery: From Transanal Endoscopic Microsurgery to Robotic Surgery

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13.1 A Brief History of a Long-Awaited Surgery

Rectal cancer treatment has advanced in nearly 300 years from producing hopeless morbid outcomes to being a potentially curative treatment, with constant improvements in quality of life.

The first description of the signs and symptoms of rectal cancer date back to 1376 [1], but no attempts to excise it were reported until 400 years later, and its excisional treatment maintained only a palliative purpose until the early eighteenth century [1], when the so-called posterior excision was described. This was a fairly rudimentary and disruptive technique, which remained popular until the 1940s [2]. Subsequent approaches, from the notorious Kraske to the York-Mason techniques were mere variants of this first approach [1, 3].

Early attempts to exploit an abdominal route for the resection of tumors were mostly experimental, sometimes accidental and, above all, performed with little attention to oncological principles [1, 2]. Excisional procedures utilizing the perineal, vaginal and sacral approaches prevailed until Miles' abdominoperineal resection in 1908 revolutionized the principles for a correct oncological resection [4]. The consequent improvement in survival caused attention to shift towards procedures ensuring sphincter preservation and better functional outcomes [5].

In 1948, rectal cancer surgery by anterior resection was introduced [6] and later technological advancements, such as the circular stapler in 1977, helped to develop and refine this technique [7–10]. From the establishment of the anterior resection

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steps by Dixon, blunt or manual presacral pelvic dissection for rectal cancer constituted the technique of choice [6]. However, this type of dissection was inevitably burdened by the risk of breaching the mesorectum by not following predefined planes, and consequently leaving residual cancer-containing mesorectum within the pelvis [6]. At this stage, the worldwide 5-year survival rates were only 45–50% for all curable stages and the expected local recurrence rates were 30–40% [11].

To Heald goes the merit to have recognized that the midline hindgut (rectum) and its mesorectum were embryologically derived together and to have introduced the concept of "total mesorectal excision" in 1982 [11]. Total mesorectal excision, which involves sharp en-bloc resection of the tumor and mesorectal tissue to the level of the levator muscles, rapidly became the gold standard for anterior rectal resection for rectal cancer [12].

At the same time, however, another revolution was underway: the transanal route.

13.2 The Transanal Revolution: Transanal Endoscopic Microsurgery

Transanal endoscopic microsurgery (TEM), as it was introduced in the 80 s, constituted an unthinkable revolution of what was still considered a disruptive and debilitating surgery [12].

TEM was first introduced as a valid alternative to resect adenomas not suitable for local or colonoscopic excision [12]. It was soon clear, however, that the technique was not only technically superior to the standard local excisions performed with the anal retractor, but it could also be considered a viable alternative to extensive resections for benign polyps at first, with good clinical and oncological outcomes [13–16].

There are, however, few but still important aspects that prevented a larger adoption of a life-saving technique.

The major drawback of this technique is that many aspects of its oncological safety are still debated. Indeed, local excision results in closer resection margins and does not allow for sampling of lymph nodes [17]. Additionally, adequate local staging methods utilizing either intrarectal ultrasound or pelvic magnetic resonance imaging have allowed only a small group of patients with distal rectal tumors to be candidates for a transanal local excision due to accuracy issues. Emerging technology allowing improved exposure has potentially made transanal approaches more feasible [17, 18]. For the above reasons, TEM is now recommended for small (<3 cm) and low grade (well-to-moderately differentiated) early-stage rectal cancers (T1N0), according to the international guidelines [19, 20]. Nonetheless, in high volume centers TEM has been proved to be feasible and oncologically safe even for localized tumors that extend into the muscularis propria (T2N0), and the very different oncological behavior of some of these tumors is the basis of fervent debate and research on this topic [21]. Local excision can also be offered as a palliative measure to address local disease in patients with advanced lesions (T3 or above, N1 or above) who are unable to safely tolerate a major abdominal surgery [15].

Another aspect concerns technical issues. TEM is a demanding technique that has a slow learning curve and that remains challenging even after the latest technological advancements and modification of the traditional instrumentation [15].

Lastly, TEM requires a specific set of dedicated instrumentation and the purchasing costs may constitute an issue. However, as always, the economic evaluation of a surgical procedure should take into account both the direct costs deriving from the purchase of the instrumentation, and the indirect costs deriving from occupation of the operating room and total charges for the patient and personnel. The question is whether, considering the early discharge, the possibility of TEM being an outpatient procedure, and the lower complication rates, those indirect costs could counterbalance the direct cost related to the purchase of the equipment and thus make TEM more cost-effective [17].

The indications for TEM overlaps those for endoscopic resection of rectal polyps. In the late 90 s, endoscopy was advocated as a diagnostic technique and a therapeutic method. First, large piecemeal snare ablations were reported. Then, the use of endoscopic electrosurgical knives made it possible to achieve en-bloc resection, known as "endoscopic submucosal dissection" [16]. The sharp increase in endoscopic resection of rectal polyps made the indications for TEM questioned [16].

However, it has to be remembered that TEM, by its nature, offers a surgical excision with higher en-bloc resection rates, and a good balance between complications and oncological outcomes still supports the superiority of surgical excision by TEM.

13.2.1 The Technique of Transanal Endoscopic Microsurgery

In summary, TEM consists of the full-thickness excision of rectal lesions located from the anal verge up to the pelvic brim, relying on a 3D magnified vision allowed by sophisticated lens technology, and the subsequent closure of the rectal defect [21–23].

The procedure is performed using a special proctoscope of 4 cm in diameter available in lengths of 12 cm and 20 cm. The rectum is insufflated with carbon dioxide at 10–15 mmHg. This can be achieved with the use of specific or usual laparoscopic CO_2 insufflators [21–23]. The optical six-fold increase and the stability provided by the equipment, attached to the operating table, allows for an excellent view of the rectum and lesion [22]. Patient positioning is strictly dependent on the side of the lesion (e.g., prone for anterior lesions, supine for posterior lesions) [21–23].

13.3 A Simplified Technique: Transanal Minimally Invasive Surgery

More recently, a variation of the previous technique has been proposed that combines the laparoscopic approach with TEM principles [24].

The aim was initially to avoid the costs deriving from purchase of the dedicated TEM instrumentation, since the proposed technique, the transanal minimally invasive surgery (TAMIS), could be performed using the available laparoscopic equipment [25]. The second purpose was to shorten the learning curve of transanal surgery [25]. The rationale for the introduction of this modified and simplified technique was that addressing these two major disadvantages of TEM could result in a larger spread of transanal excision for rectal cancer, with its related benefits [26].

Several transanal ports have been introduced for this approach, including either disposable or reusable single-ports (Fig. 13.1), [27].

Differently from TEM, by constitution a single-surgeon procedure, TAMIS requires the presence of an assistant surgeon to control the camera, a requirement that may cause also a loss in the stability of the image during the procedure [27].

Standard laparoscopic instruments are used and, once they are inserted, the surgeon performs the procedure with an excisional technique that reproduces the steps described for TEM. However, most single ports have only three portal entries so that aspiration of the cautery smoke is not continuous. Finally, access to the lower rectum might be more difficult due to the significant need for instrument angulation. On the other hand, access to the upper rectum may be limited by rectal folds in some patients [27]. These characteristics may limit the indication for TAMIS, making this type of excision best suited for middle rectal lesions [27].

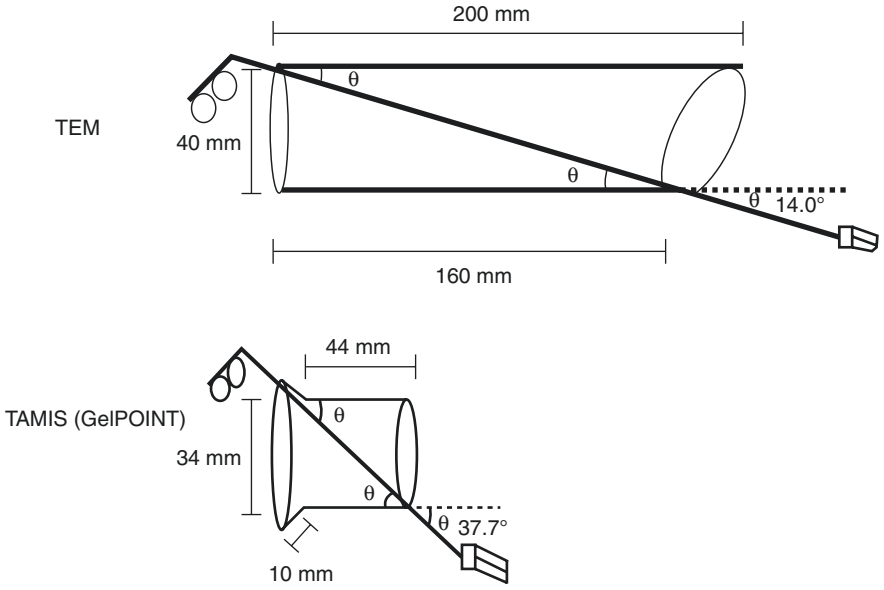

Fig. 13.1 Comparison of ports used in transanal endoscopic microsurgery (TEM) and transanal minimally invasive surgery (TAMIS). Reproduced from Martin-Perez et al. [27] with permission of Springer Nature

13.4 Robotics in Transanal Surgery

Robotics applied to transanal surgery constitutes nothing more than the natural translation of TEM principles into the modern era [28, 29]. Experiments with robotic transanal surgery date back to 2010, in the form of preclinical studies based on dry laboratory [28] and cadaveric models that initially showed the feasibility of this approach using the da Vinci robotic cart [29, 30]. The first robotic transanal resection in a human case was performed in 2012 [31]. Twelve articles were published between 2013 and 2022; of these, five were case reports, three were case series, two were prospective cohort studies, one was a retrospective cohort study, and one was a phase II clinical trial [32].

There are many variables involved in robotic transanal resection. The first is the platform used [32].

The studies reported using various robotic platforms, including the da Vinci Si, da Vinci Xi, da Vinci single port, and the Flex robotic system [32]. Other variables regard patient positioning, which almost in all papers depends on the location of the lesion [33]. The rationale for using robotic systems for this type of surgery lies in the augmented dexterity and improved ergonomics coupled with the 3D vision offered by these platforms. Ideally, a robotic approach could allow also access to larger, more proximal and more complex lesions, including circumferential lesions [33]. However, according to some authors, one of the advantages of the da Vinci Xi over laparoscopic systems is the higher maneuverability of the robotic arms, which allows for easier access to rectal lesions regardless of their location, while laparoscopic transanal excisions remain highly position-dependent, becoming more difficult to perform if the patients are not placed in the right position [34]. Since robotic transanal procedures are still in development, a clear approach that could be considered the gold standard is not yet defined [34, 35].

13.5 Conclusions

The treatment of cancer of the rectum is historically among the most debated. The management of rectal cancer has evolved both in technical and technological terms. The development of novel parallel therapies, such as radiotherapy, has contributed to make TEM a viable option even for more advanced rectal cancers. Besides, the robotics revolution has not left the field of transanal surgery untouched and may become the future of rectal surgery.

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