

The transversus and rectus abdominis musculoperitoneal (TRAMP) flap

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ABSTRACT Due to sufficient vascular connections between the deep inferior epigastric artery, the superior epigastric artery and the lower posterior intercostal arteries within and below the rectus abdominis muscle, it is possible to raise a part of the inner abdominal wall composed of the rectus abdominis muscle, the epigastric part of the transversus muscle and the underlying fasciae and peritoneum as a composite flap reliably nourished exclusively by the deep inferior epigastric artery. This transversus and rectus musculoperitoneal (TRAMP) flap provides a tissue plate of an area at least 10 x 15 cm and 0.5 to 1.5 cm thickness, which easily reaches the deep pelvis and can even be transposed to the level of the vulva and perineum. Harvesting the flap is performed through a standard midline hypo/epigastric laparotomy. The anterior rectus sheath and the obliquus fascia which are the essential structures for supporting the strength and integrity of the anterior abdominal wall are left in place, thus donor site repair is not mandatory and morbidity is low.

The flat musculofascioperitoneal tissue plate of the TRAMP flap represents a versatile new means for pelvic support, compartmentalization and therapeutic angiogenesis with various applications, such as pelvic floor reconstruction, pelvic inlet plasty and pelvic wall plasty. The dimension and tissue compliance also render the TRAMP flap a novel attractive technique for vulvovaginal reconstruction after pelvic exenteration. Since the mesothelium of the peritoneal layer must be replaced by squamous cell epithelium from the adjacent tissues, a strip of unirradiated original vagina should be incorporated into the tubularized TRAMP flap for accelerating the completion of the squamous cell surface of the neovagina. The tubularized TRAMP flap with the peritoneal side endolumi-

nally is therefore best suited for partial vulvovaginal reconstruction, after anterior or posterior exenteration. For complete vaginal reconstruction after total exenteration, the tubularized TRAMP flap with the muscular side endoluminally covered with a skin mesh graft appears to be a promising new procedure. We must wait for more experiences with more patients and long-term results for definitive evaluation.

Key words musculoperitoneal flap, TRAMP, vulvovaginal reconstruction, exenteration, pelvic reconstruction

INTRODUCTION The TRAMP flap is the first representative of a new flap type derived from the inner abdominal wall layers. It was originally developed as a means for partial vulvo-vaginal reconstruction after anterior or posterior pelvic exenteration (1) based on the results of a cadaver study of the vascular anatomy of the inner abdominal wall (2). Five year experience with the TRAMP flap proved its reliability and broadened its application potential. The risk of stenosis and obliteration of the TRAMP neovagina during the process of exchanging the mesothelium for squamous cell epithelium, can be significantly reduced by using the muscular side of the flap (instead of the peritoneal side) together with a skin mesh graft.

VASCULAR ANATOMY OF THE INNER ABDOMINAL WALL At the musculoperitoneal level, the deep inferior epigastric artery (DIEA) nourishes the distal two-thirds of the rectus abdominis muscle. The DIEA anastomoses via choke connections with the terminal branches of the superior epigastric artery, which predominantly supplies the proximal part of the rectus abdominis muscle. The proximal 5-7 cm portion of the DIEA runs directly adjacent to the peritoneum in the umbilical fold, giving off several muscular and peritoneal branches, whereas the medial and distal segment of the artery is embedded in the rectus abdominis muscle.

The left and right DIEAs are connected to each other by various small-calibre arteries that cross the linea alba, epifascially or subfascially. Above the umbilicus, usually three or four main vessels of the DIEA branch off laterally to the adjacent transversus and obliquus internus abdominis muscles. They are

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interconnected to the lower posterior intercostal arteries by various anastomosing vessels via choke connections.

Approximately 40% of the vessels of the anterior body wall run within or under the rectus abdominis muscle including the choke connections to the intercostal and superior epigastric artery.

FLAP DESIGN The TRAMP flap consists of the entire rectus abdominis muscle in continuity with an ipsilateral epigastric part of the transversus abdominis muscle, the posterior rectus and transversalis fascia and the underlying parietal peritoneum. Blood supply is provided by the DIEA. The segmental motor innervation by intercostal nerves is interrupted as a consequence of the flap elevation. Following transposition into the pelvis, the epigastric musculofascioperitoneal tissue plate is used

1. flat for pelvic floor reconstruction, pelvic wall plasty or pelvic inlet plasty,
2. partially tubularized, peritoneal side endoluminal for partial (vulvo)vaginal reconstruction after anterior/posterior exenteration,
3. completely tubularized, muscular side endoluminal covered by a skin mesh graft for complete (vulvo)vaginal reconstruction after total exenteration.

SURGICAL PROCEDURE The elevation of the TRAMP flap necessitates a hypogastric and epigastric midline laparotomy. The umbilicus should be circumcised at the site of the planned TRAMP flap. The selection of either a right or left TRAMP flap is based on the site of scars of previous abdominal operations and overall reconstructive needs with respect to the ablative pelvic operations. In the case of a former right subcostal incision for cholecystectomy, a right TRAMP flap may not be safe. If ostomies are necessary for urinary or fecal diversion, the contralateral side is used for the TRAMP flap. The rectus abdominis muscle is first completely dissected from the anterior rectus sheath. In order to avoid shearing off, the posterior fascia and parietal peritoneum are anchored to the medial margin of the rectus muscle. The rectus muscle together with the posterior rectus fascia and parietal peritoneum is transected at the tendinous intersection closest to the costal insertion of the muscle. The dissection is then continued laterally to the linea semilunaris, which is separated craniocaudally from the rectus muscle and the transversus abdominis muscle in the epigastric region for a length of 10 to 12 cm. The preparation is then extended further laterally along the surface of the transversus abdominis muscle for 5-10 cm, taking care to include the distal posterior intercostal neurovascular pedicles into the TRAMP flap. The epigastric part of the transversus muscle with the overlying intercostal neurovascular bundles and underlying parietal peritoneum is cut through at the level of the anterior axillary line.

In the hypogastric region, the transversus muscle is no longer part of the TRAMP flap. The further caudal elevation conti-

nues by transection of the posterior rectus sheath and peritoneum towards the arcuate line. Between the arcuate line and the origin of the rectus muscle at the pubic bone, only the parietal peritoneum must be incised ensuring that the nourishing deep inferior epigastric vessels are not severed. Likewise, a minor branch of the epigastric vessels leading into the peritoneum at that location should be preserved and integrated into the TRAMP flap. The fully mobilized flap can be easily transposed into the pelvis.

For pelvic floor reconstruction, the epigastric musculofascioperitoneal tissue plate is fixed, peritoneal side intraabdominally to the arcus tendineus at both pelvic side walls. By more cranial placement, the TRAMP flap can be used as pelvic inlet plasty to retain the small bowel from the lesser pelvic cavity, thus preventing its damage in case of postoperative high dose pelvic irradiation. The overall flap area can be enlarged by suturing the rectus abdominis muscle side to side medially. The tissue plate is then sutured to the psoas muscles, promontorium and symphysis. A TRAMP flap is favourable as pelvic wall plasty for the CORT treatment (3) in obese patients with a fatty omentum majus. In this situation, the muscular side of the TRAMP flap should face the tumor bed with the overlying guide tubes. An omentum majus flap is sutured to the peritoneal side of the TRAMP flap.

For vulvovaginal reconstruction following anterior or posterior exenteration, with an epithelialized strip of the original vaginal wall left in place, the epigastric musculofascio-peritoneal tissue plate of the TRAMP flap is proximally tubularized over a stent of the desired neovaginal size with the peritoneal side endoluminally. From the perineal route the proximally open TRAMP flap tube is then sutured to the remaining vaginal wall strip and the vulvoperineal resection margins. If the formation of a complete neovagina after total exenteration is desired, the epigastric musculofascioperitoneal tissue plate of the TRAMP flap should be tubularized at full length with the muscular side endoluminally. After fixation of the distal TRAMP flap tube to the vulvoperineal resection margins, a split thickness skin graft is harvested from the inner thigh and meshed with an expansion factor 1:2. The skin mesh graft is then spread over a suitable perforated glass stent. By inserting the stent into the TRAMP flap tube, the muscular surface of the flap is completely covered with the skin graft.

The musculofascioperitoneal defect caused by the elevation of the flap is left untreated. The abdominal incision is closed by modified Smead-Jones sutures, incorporating only the anterior rectus fascia into the far and near stitch at the donor site of the TRAMP flap.

In the cases of pelvic floor reconstruction, pelvic inlet plasty and pelvic wall plasty, the viability of the TRAMP flap is checked in the first postoperative week by pelvic MRI with contrast media. If (vulvo)vaginal reconstruction has been per-

formed, the TRAMP flap should be inspected through the glass stent which is left in place for the first 7 to 10 days postoperatively. Thereafter the stent should be replaced and cleaned daily. In the second postoperative week, the stent should be worn day and night, in the third postoperative week it should be kept intravaginally only during the night. Thereafter, the patient is encouraged to begin regular intercourse or wear the stent overnight for further two to three months.

CLINICAL EXPERIENCE Since 1993 I have performed 16 TRAMP flaps for pelvic floor reconstruction (n=3), pelvic inlet plasty (n=2), pelvic wall plasty (n=3), partial vulvovaginal reconstruction (n=4), total vulvovaginal reconstruction (n=4). Flap survival was 100% in all cases. No donor site morbidity became apparent, except a visible epigastric abdominal wall bulging in a 71 year old patient, whose general laxity of the skin and subcutaneous fatty tissue was evident before the operation. The intended functional goals were reached in all cases of pelvic floor reconstruction, pelvic inlet plasty and pelvic wall plasty. All four patients with (vulvo)vaginal reconstruction following posterior or anterior exenteration retaining a strip of original vaginal wall, had excellent or good anatomical and functional results at a follow-up time from 27 to 54 months. Their reconstructed vaginas were 8-10 cm long, 4 cm wide and showed good tissue compliance. Three patients reported on having satisfying intravaginal intercourse. The mesothelial layer of the peritoneum was replaced by squamous cell epithelium from the adjacent vulvar skin and residual vaginal strip. After 3 months, no differences between original vagi-

nal and neovaginal surfaces were clinically visible. At the border between original perineal skin and neoperineum, no superficial scar formation could be seen.

Despite an uneventful postoperative course, two total vaginal reconstructions performed with the peritoneal side of the TRAMP flap endoluminally became obliterated within 4 months. Because of these failures, I modified the surgical technique for total vaginal reconstruction by using the muscular side together with a meshed split thickness skin graft as neovaginal epithelial lining. The first experience with this procedure is promising, however, the results with more patients and longer follow-up are required for definitive evaluation.

ACKNOWLEDGEMENT This work has been supported by a grant from the Else Kröner-Fresenius Foundation, Bad Homburg v.d.H., Germany.

REFERENCES

1. Höckel M. The transversus and rectus abdominis musculoperitoneal (TRAMP) composite flap for vulvovaginal reconstruction. *Plast Reconstr Surg* 1996; 97:455-459.
2. Konerding MA, Gaumann A, Shumsky A, Schlenger K, Höckel M. The vascular anatomy of the inner anterior abdominal wall with special reference to the transversus and rectus musculoperitoneal (TRAMP) composite flap for vaginal reconstruction. *Plast Reconstr Surg* 1997; 99:705-710.
3. Höckel M, Schlenger K, Hamm H, Knapstein PG, Hohenfellner R, Rösler HP. Five-year experience with combined operative and radiotherapeutic treatment of recurrent gynecologic tumors infiltrating the pelvic wall. *Cancer* 1996; 77:1918-1933.