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ORIGINAL ARTICLE

The Swift operation: a modification of the Leiden nerve-sparing radical hysterectomy

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Abstract In 2002, our group introduced an operation to avoid damage to the pelvic autonomous nerves during radical hysterectomy that proved to be feasible, effective and safe. During the last five years, we have adapted our surgical technique to make this procedure easier and safer in terms of radicality. We report on the changes in the surgical approach and the results in the first 15 consecutive patients. The Swift operation is more radical in the area of the uterosacral ligaments than the original operation, and it dissects the hypogastric nerve free under direct vision. In the area of the parametria, it is more radical in the deep lateral part. The vascular parametrial tissue is dissected and separated ventrally from the ureters. From October 2006 to February 2007, 15 consecutive patients with cervical cancer stage IA2 to IB2 underwent the Swift operation. The extra operating time amounted to 20 min, which was similar to the original operation, and with no extra blood loss. The suprapubic catheter was removed after a median of five days. Up until now (February 2008), no recurrences have been seen in these patients. It was concluded that the Swift procedure is easy to perform and that it offers advantages over the original operation in terms of safety and radicality.

Keywords Nerve-sparing · Cervical cancer · Radical hysterectomy · Surgical technique

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Introduction

In 2001, we proposed a surgical technique to avoid damage to the autonomous nerves in the pelvis during radical hysterectomy [1]. The rationale for preserving these nerves during surgery is to avoid the well-known sequelae of nerve damage, such as impaired bladder function [2], rectal motility disorders and sexual dysfunction [3–5]. Our nerve-sparing surgical technique was based on extensive cadaver studies [6] and the experience of Japanese surgeons [7, 8], and an approach was chosen to make the technique applicable for Western patients with a higher mean body mass index (BMI) and different disposition of fat in the pelvis as compared to Asian women. Our proposal was not an entirely new form of radical hysterectomy but, rather, the description of individual nerve-sparing steps that could be incorporated into any particular type of radical hysterectomy. The technique was, therefore, easy to follow and adopt [9, 10].

We have shown that the nerve-sparing technique is feasible and that nerve damage can actually be avoided [11]. Furthermore, the 5-year survival rate before and after the introduction of the nerve-sparing technique in our department did not change. Preliminary data on the objective sexual function following nerve-sparing surgery indicated that blood flow response following sexual arousal is not different between patients who underwent nerve-sparing radical hysterectomy on one hand and healthy controls on the other.

The winds of change do also blow in surgery and, over the years, we have considered adaptations to our technique to make it easier and safer in terms of radicality. In this paper, we report on these modifications and we demonstrate the feasibility of the modified approach in the first 15 consecutive patients.

Patients and methods

From October 2006 to February 2007, 15 consecutive cervical cancer patients who underwent radical hysterectomy were included in a feasibility study. An adaptation of the original nerve-sparing operating technique [1] was performed, which is described in detail below. Clinical characteristics of the patients, the tumours and the perioperative course were recorded. Patients were admitted to the hospital for around a week; discharge was dependent on their condition and home situation. All patients received a suprapubic bladder catheter at the end of the operation. On the fifth postoperative day, the bladder function was tested and urinary retention measured. When there was spontaneous micturition and the urinary retention was less than 100 ml, the catheter was removed under antibiotic prophylaxis.

Surgical technique

The successive steps of the adapted nerve-sparing operation are summarised in Table 1. To obtain a better insight into the neuroanatomical structure of the pelvic autonomous nerves, we refer to a detailed review on this subject [12].

The operation results in a tissue specimen containing the uterus with parametrium and paracervical tissue and two distinct tissue flaps on both sides: a horizontal mesometrial flap containing the uterine vessels and the surrounding tissue and a dorsal tissue flap containing the uterosacral ligament, rectal pillar, peritoneum and subperitoneal connective tissue. The horizontal vascular mesometrium contains the uterine artery and veins, lymphatic vessels, small lymph nodes, uterovaginal branches of the autonomic pelvic plexus, loose connective tissue and, usually, small-calibre fatty tissue. The dorsal tissue flap, the ligamentous

Table 1 Steps of the adapted nerve-sparing operation

The steps of the Swift operation
Transect the round ligaments and open the peritoneum of the broad ligament above the level of the common iliac arteries
Identify and dissect the ureters from as cranially as possible up to the entrance of the ureteral canal
Lymphadenectomy along the external iliac vessels, the common iliac artery, the hypogastric artery, from the obturator fossa and the presacral area, clearing all of the lymph node-bearing fatty tissue. Also, the area lateral to and underneath the superior vesical arteries ("lateral parametrium") is cleared from the lymphatic tissue
Develop the parietal spaces (see [14] for a more extensive description) by blunt dissection of the loose connective tissue lateral to the superior vesical arteries up to the bifurcation of the iliac vessels
Identify the origin of the uterine vessels from the pelvic side wall and dissect along the distal border of the vessels to separate the uterine vessels ("mesometrium") from the underlying bladder mesentery. The bladder mesentery consists of the inferior vesical artery and veins, lymphatic vessels, fatty tissue and the distal part of the inferior hypogastric nerve plexus, with branches to the ureter, bladder, vagina and clitoris
Transect the uterine vessels at their origin and dissect this tissue (containing blood vessels, lymph vessels, fatty tissue and loose connective tissue) down along the pelvic side wall, then turn upwards in a medial direction, over the ureter to its medial side, using haemoclips or LigaSure sealing (Fig. 3)
Develop the presacral space by blunt dissection between the rectum medially and the ureters laterally
Put the peritoneum flap attached to the rectum under tension in a clamp and identify the hypogastric nerve system attached to the subperitoneal and dense connective tissue, grasp it in a Babcock clamp and dissect it laterally. The hypogastric nerve can be identified best at the entrance of the ureteral tunnel. At this level, the autonomous nerves run parallel to and closely dorsally to the ureter
Open the pouch of Douglas peritoneum and develop the prerectal space
Cut the peritoneal flap that has been separated from the hypogastric nerve halfway round the circumference of the rectum and continue the dissection to include all of the uterosacral ligaments close to where the ureters enter the ureteral canal
Open the bladder peritoneum, cut the supravaginal septum and dissect the bladder down from the cervix and the vagina
Open the rest of the ureteral canal (anterior leaf of the vesico-uterine ligament) using an Oberholt clamp or Uchida's ureter spoon
Remove the ureter from the posterior leaf of the vesico-uterine ligament by dissecting the loose connective tissue embedding the ureter. The ureters are now completely freed up to their entrance into the bladder
Place clamps or LigaSure on the thin sheath of dense connective tissue along the cervix and vagina. This tissue has been called the medial part of the posterior leaf of the vesico-uterine ligament, paracolpium or vesico-vaginal ligament. It is almost continuous to the distal attachment of the uterosacral ligaments
Place Burke clamps on the vagina and cut the vagina below these clamps
Remove the uterus with the mesometrium wings and the long-tailed uterosacral ligaments
Close the vaginal cuff with interrupted resorbable sutures
Rinse the operating field with sterile water to detect persistent venous bleeding and provide for adequate haemostasis
Close the abdomen

mesometrium, is a three-dimensional structure of dense connective tissue running in a dorsal and inferior direction and is horseshoe-shaped in the transverse plane, which encases the rectum. The hypogastric nerve runs laterally to it. The tissue specimen resembles the silhouette of a Swift bird (Fig. 1) and, therefore, the operation is called the Swift operation.

Compared to the original nerve-sparing operation, there are three differences. First, in the Swift operation, the uterosacral ligament is not divided any more into a medial and lateral part. The hypogastric nerve is dissected free from the uterosacral ligaments and the surrounding tissue, permitting a far more radical resection of the entire uterosacral ligaments and rectal pillars (Fig. 2 right). In this way, the hypogastric nerve is approached from the lateral side as opposed to our previous technique, which approached it medially.

Second, the parametrial resection has a different direction of the dissection plane. In the original operation, it was like the bow of a ship running from a ventro-lateral to a dorso-medial direction. In the Swift operation, the dissection plane follows the shape of the tip of an Ionic column of an ancient Greek temple (Fig. 3). The mesometrial tissue is dissected free from the ventral side of the ureter and stays attached to the uterus as a horizontal tissue flap resembling the wings of a Swift.

Third, the resection of the lateral part of the posterior leaf of the vesico-uterine ligament, as described previously [1], is only performed when it is necessary to obtain radically free surgical margins in this area (R0 status).

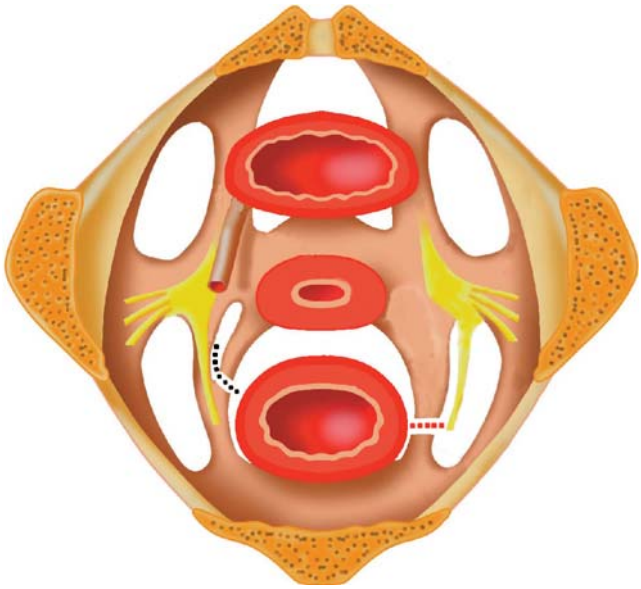

Fig. 2 Dissection of the uterosacral ligament in the Swift operation (right)

Results

The results of the feasibility study are shown in Table 2. In all patients, the Swift operation could be performed. The amount of blood loss, operating time and admission time were within the normal ranges for this kind of surgery [1, 13]. The suprapubic catheter was removed between 4 and 10 days postoperatively (mean 6 days, median 5 days). In all cases, there were radically (> 5 mm) free margins (R0 status) and in three patients, lymph node metastases were found in a total of six nodes: dorsomedially to the external iliac vein (two nodes); between the external iliac artery and vein (one node); laterally to the common iliac artery (one node) and in the medial part of the obturator fossa (two nodes). The extra operating time due to the Swift procedure amounted to 20 min, which means that the Swift procedure takes just as long as our former nerve-sparing technique.

Discussion

This clinical study shows that the Swift procedure was easy to perform and feasible in all 15 consecutive cases. The postoperative restoration of bladder function was illustrated by spontaneous micturition with a urinary retention of less than 100 ml after a median of five postoperative days. Due

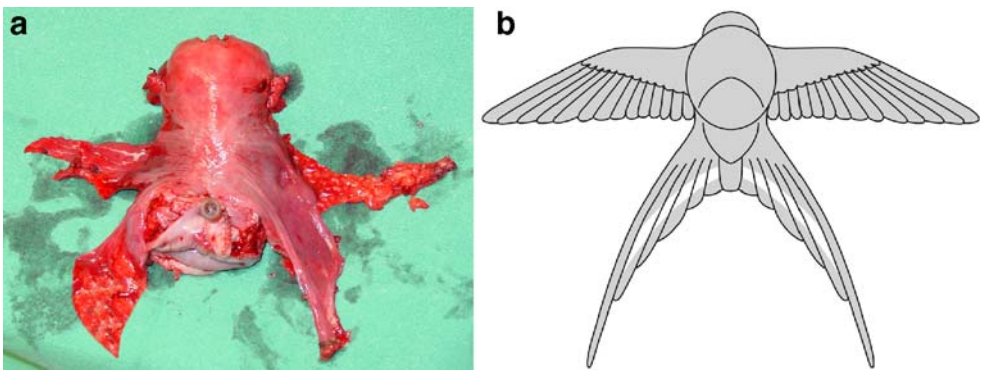

Fig. 1 Comparison of the freed tissue specimen (**a**) with a Swift bird (**b**)

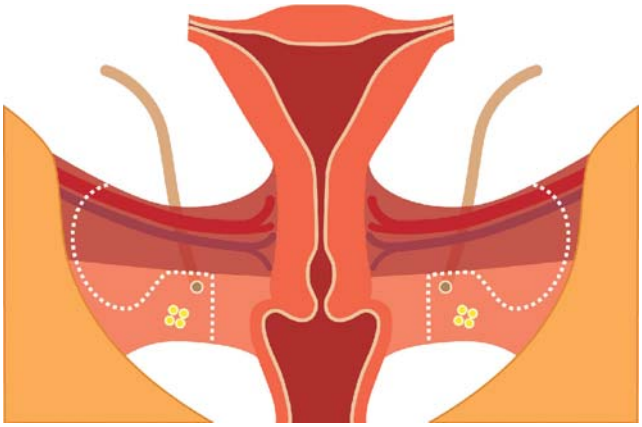

Fig. 3 Dissection plane of the Swift operation

to the short follow-up in this study, no data regarding the long-term effects on the bladder function can be provided.

The adaptation of the original operation

The adaptation of the original Leiden operation of nerve-sparing radical hysterectomy deserves some explanation. The first difference concerns the sparing of the hypogastric nerve fibres in the vicinity of the uterosacral ligaments. These fibres originate from the superior hypogastric plexus that is located ventrally from the promontory and run attached to the lateral side of the peritoneum that covers the rectum. This peritoneal sheath is normally opened to identify the ureter and obtain access to the presacral area. More distally, the hypogastric nerve is embedded in loose connective tissue that is part of the most lateral section of the uterosacral ligament. By stretching the peritoneal leaf lateral to the rectum, the hypogastric nerve can easily be identified on its lateral side and dissected free from all adjacent tissue. This dissection can be continued to the point were the nerves run dorsally from the ureter in front of the beginning of the ureteral tunnel. Here, the nerve fibres fuse with the parasympathetic fibres from the sacral roots S2–S4 to form the inferior hypogastric plexus. By dissecting the hypogastric nerve free, a very radical resection of rectal pillars, uterosacral ligaments and peritoneal and subperitoneal tissue can be achieved, without any fear of damaging the nerves. We perform this step with the use of LigaSure®. Dissecting the hypogastric nerve free in this way is actually easier than the splitting of the uterosacral ligament, as described previously [1], because the nerve is in sight during the whole procedure. Also, in obese patients, the identification of the nerve in this area is no problem. An additional advantage of the Swift approach is that it is no longer necessary to open the peritoneum covering the uterosacral ligaments. This was mandatory in the original operation to permit the splitting of the uterosacral ligament into a medial and a lateral part, but it often caused extra blood loss due to persistent oozing from the peritoneal edges in that area.

The second difference regards the dissection plane during the parametrial resection. In the Swift operation, the resection starts at the origin of the uterine vessels at the pelvic site wall. Then, it runs in a dorsal direction, bends medially and slightly ventrally (like the shape of an Ionic column) and follows a course just ventrally from the ureter. Medially from the ureter, it runs dorsally again (Fig. 3). In

Table 2 Results of the study

Consecutive number	Age	Stage	Tumour diameter at surgery (cm)	Cell type	Operating time (min)	Blood loss (m)	Hospitalisation (days)	Removal of suprapubic catheter (days)	Resection status (margins)	Remarks
1	33	Ib1	2.9	adeno	210	450	6	5	R0	
2	42	Ib1	3.5	squamous	180	750	7	5	R0	
3	61	Ib2	5	squamous	180	1,200	8	7	R0	1/30 nodes +
4	45	Ib1	3	squamous	180	400	8	10	R0	
5	45	Ib1	2	squamous	240	800	8	6	R0	
6	50	Ib1	3	adeno	240	350	8	5	R0	
7	29	Ib2	4.5	squamous	195	630	8	8	R0	3/33 nodes +
8	30	Ib1	2.5	squamous	180	700	7	5	R0	
9	36	Ib1	3	squamous	180	700	9	7	R0	
10	53	Ia2	1.5	squamous	240	800	7	5	R0	
11	57	Ib1	3.9	squamous	180	800	10	9	R0	
12	35	Ib2	4.5	adeno	210	400	8	7	R0	
13	46	Ib1	3	squamous	210	380	7	5	R0	
14	52	Ib1	2.5	squamous	180	400	8	5	R0	
15	33	Ib2	6	adeno	150	500	6	4	R0	2/29 nodes +

this manner, the entire vascular part of the parametrium ("mesometrium") remains attached to the lateral side of the uterus that is removed as a tissue specimen. The nerve-bearing tissue is avoided more effectively with the new technique.

By staying ventrally to the ureter, the hypogastric plexus can never be damaged, as it is always located dorsally from the ureter. In this sense, the Swift procedure is safer for avoiding the nerves than the previously described "bow-of-a-ship" dissection.

It can be stated that the Swift procedure is safer in terms of nerve-sparing compared to the original operation both at the uterosacral and the parametrial areas. At the same time, it is as radical in the parametrial resection and more radical in the uterosacral part.

The deep lateral parametrium

In the Swift operation, as in the previously proposed nerve-sparing radical hysterectomy, the deep lateral part of the parametrium is not removed. Is this a problem from a radicality point of view? We think not. We have seen no significant difference in the survival or local recurrence rate since we started with nerve-sparing surgery in 2001/2002. Some concern about the importance of removing the deep lateral portion of the parametrium has been expressed by the authors of the so-called "giant section" studies, in which the whole of the parametrium from the uterus to the pelvic side wall was embedded for pathology assessment. In these studies also, lymph nodes in the deep lateral part of the parametrium were found. In the giant-section studies, parametrial resection is performed before the pelvic lymphadenectomy, making it impossible to distinguish these nodes as "deep lateral parametrial" or "deep medial obturator." We have found that, after an extensive and deep lymphadenectomy in which the lymph-bearing tissue dorsally from the superior vesical arteries is also removed, apart from the autonomous nerves, hardly any tissue remains in the area that is called the deep lateral parametrium. The only tissue that can be found is directed in a more distal course towards the bladder and is to be regarded as bladder mesentery. Furthermore, in the giant section technique, it is not possible to distinguish between parametrium and uterosacral ligamentous tissue.

Another argument against the obsession to remove the deep lateral part of the parametrium is the rate of lymph node metastases in this area. Winter et al. [14] found lymph node involvement in the deep lateral parametrium in 2.2% of FIGO stage Ib1 cervical cancer patients. Burghardt et al. [15] demonstrated, in stage Ib1–IIb patients with negative pelvic lymph nodes, the likelihood of tumour involvement of the deep lateral parametrium to be only 0.9–1.3%.

Total mesometrial resection

The Swift operation is inspired by and resembles the total mesometrial resection (TMMR) described by Höckel et al. [16]. This operation is based on the hypothesis that the local spread of cervical cancer cells is not a random process, but is guided by positional information within a defined permissive area. This area is the adult state of the embryological field through which the uterine cervix has developed. The theory behind TMMR indicates that this area, called the morphogenetic unit (MGU), should be completely removed during radical hysterectomy, but that it is unnecessary to remove tissue outside the borders of the MGU. The MGU consists of the vascular parametrium ventrally from the ureter and the uterosacral ligament/rectal pillar complex as far dorsally as half way round the circumference of the rectum. Therewith, the structure of the MGU closely resembles the shape of the tissue specimen after a Swift operation.

In the TMMR theory, the autonomous pelvic nerves, the posterior leaf of the vesico-uterine ligament and the deep lateral part of the parametrium are outside the MGU and, as such, represent no risk for local tumour spread. The theory of Höckel et al. is very interesting from an oncological point of view, because it suggests an orchestration of the way cancer cells spread in the vicinity of the primary tumour. The total mesorectal excision (TME) is based on the same principle and has caused a revolution in the treatment results of rectal cancer. Höckel's group recently published the results of 126 TMMR operations [17], and the results are spectacular, as well as better than the current state-of-the-art results in the surgical treatment of cervical cancer [13].

The TMMR and the Swift operations have reached a similar end point, albeit via different routes. The main difference between the two operations is a far more extensive lymphadenectomy in TMMR. This is done with a therapeutic intention to dispense with adjuvant radiation in all cases. In the Swift operation, the adaptations described in this paper were derived by the search for an optimal combination of sparing the autonomous pelvic nerves on the one hand and the radical removal of cervical cancer on the other. TMMR is based on a new and promising theory on the positional spread of cervical cancer cells. Sparing the autonomous nerves in the TMMR operation is not a goal in itself, but a logical consequence, because the nerves are not part of the MGU.

Whatever approach is followed in the surgical treatment of cervical cancer, avoiding damage to the autonomous pelvic nerves should be an important element for the kind of radical hysterectomy that is performed. This paper, which describes the Swift nerve-sparing radical hysterectomy, provides guidelines for such an approach. It has been

developed over more than eight years of extensive study of the course and function of the pelvic autonomous nerves and the steps of pelvic surgery. It is feasible, and even easy to perform, is rational from an oncological point of view and it concurs with a recently launched theory of the local tumour spread of cervical cancer.

References

1. Trimbos JB, Maas CP, DeRuiter MC, Peters AAW, Kenter GG (2001) A nerve-sparing radical hysterectomy: guidelines and feasibility in Western patients. Int J Gynecol Cancer 11:180–186
2. Pieterse QD, Maas CP, ter Kuile MM, Lowik M, van Eijkeren MA, Trimbos JB, Kenter GG (2006) An observational longitudinal study to evaluate miction, defecation, and sexual function after radical hysterectomy with pelvic lymphadenectomy for early-stage cervical cancer. Int J Gynecol Cancer 16:1119–1129
3. Bergmark K, Avall-Lundqvist E, Dickman PW, Henningsohn L, Steineck G (1999) Vaginal changes and sexuality in women with a history of cervical cancer. N Engl J Med 340(18):1383–1389
4. Maas CP, ter Kuile MM, Laan E, Tuijnman CC, Weijenborg PT, Trimbos JB, Kenter GG (2004) Objective assessment of sexual arousal in women with a history of hysterectomy. Br J Obstet Gynaecol 111:456–462
5. Rees PM, Fowler CJ, Maas CP (2007) Sexual function in men and women with neurological disorders. Lancet 369:512–525
6. Maas CP (1999) Japanese nerve-preserving techniques in surgery for cancer of the uterine cervix. Jpn J Clin Oncol 29:517–518
7. Moriya Y, Sugihara A, Akasu T, Fujita S (1995) Nerve-sparing surgery with lateral node dissection for advanced lower rectal cancer. Eur J Cancer 31A:1229–1232
8. Kuwabara Y, Suzuki M, Hashimoto M, Furugen Y, Yoshida K, Mitsuhashi N (2000) New method to prevent bladder dysfunction after radical hysterectomy for uterine cervical cancer. J Obstet Gynaecol Res 6:1–8
9. Raspagliesi F, Ditto A, Fontanelli R, Solima E, Hanozet F, Zanaboni F, Kusamura S (2004) Nerve-sparing radical hysterectomy: a surgical technique for preserving the autonomic hypogastric nerve. Gynecol Oncol 93(2):307–314
10. Soderini A, Sardi J, Giaroli A et al (2006) Nerve sparing radical hysterectomy (NSRH) for cervical cancer (CC). Preliminary results. Int J Gynecol Cancer 16(Suppl 3):7695–763
11. Maas CP, Kenter GG, Trimbos JB, DeRuiter MC (2005) Anatomical basis for nerve-sparing radical hysterectomy: immunohistochemical study of the pelvic autonomic nerves. Acta Obstet Gynecol Scand 84(9):868–874
12. Maas CP, DeRuiter MC, Kenter GG, Trimbos JB (1999) The inferior hypogastric plexus in gynecologic surgery. J Gynecol Tech 5:55–62
13. Trimbos JB, Franchi M, Zanaboni F, Velden JVD, Vergote I (2004) 'State of the art' of radical hysterectomy; current practice in European oncology centres. Eur J Cancer 40:375–378
14. Winter R, Haas J, Reich O, Koemetter R, Tamussino K, Lahousen M, Petru E, Pickel H (2002) Parametrial spread of cervical cancer in patients with negative pelvic lymph nodes. Gynecol Oncol 84:252–257
15. Burghardt E, Baltzer J, Tulusan AH, Haas J (1992) Results of surgical treatment of 1028 cervical cancers studied with volumetry. Cancer 70:648–665
16. Höckel M, Horn LC, Hentschel B, Höckel S, Naumann G (2003) Total mesometrial resection: high resolution nerve-sparing radical hysterectomy based on developmentally defined surgical anatomy. Int J Gynecol Cancer 13:791–803
17. Höckel M, Horn LC, Fritsch H (2005) Association between the mesenchymal compartment of uterovaginal organogenesis and local tumour spread in stage IB–IIB cervical carcinoma: a prospective study. Lancet Oncol 6:751–766