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Technical Note

Omentum flap as a spacer before carbon ion radiotherapy for gynecological recurrences. A technical note

Espaceur à base d'épiploon pour radiothérapie par ions carbone dans un contexte de ré-irradiation de tumeurs gynécologiques récidivantes. Note technique

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ABSTRACT

Re-irradiation of pelvic recurrent gynecological cancer is a challenge due to the proximity of high-radiation-sensitive organs, such as the bowel and the urinary tract. Hadrontherapy for re-irradiation emerges as a safe and effective treatment with a mild rate of morbidity of surrounding normal tissue. To improve the dose to the tumor, a prophylactic displacement of organs at risk is needed, and a multidisciplinary approach is recommended. In this technical note, we report a surgical technique of omentum spacer placement for patients enrolled for carbon ion radiotherapy as re-irradiation for recurrent gynecological tumors.

Mots clés :
Ré-irradiation, Hadronthérapie
Tumeurs gynécologiques récidivantes

RÉSUMÉ

La ré-irradiation de récidives pelviennes de cancers gynécologiques est particulièrement délicate en raison de la proximité d'organes hautement radiosensibles, comme l'intestin ou les voies urinaires. Dans ce contexte de ré-irradiation, l'hadronthérapie semble être un traitement sûr et efficace, avec un taux réduit de complications au niveau des tissus sains environnants. Afin d'optimiser la dose délivrée à la tumeur, un déplacement prophylactique des organes-à-risque peut être nécessaire et une approche multidisciplinaire est alors recommandée. Dans cette note technique, nous décrivons une technique chirurgicale pour mettre en place un espaceur à base d'épiploon pour des patientes traitées par ions carbone dans un contexte de ré-irradiation de tumeurs gynécologiques récidivantes.

1. Background

The management of lateral pelvic recurrences from gynecological cancers after photon beam radiotherapy (RT) represents a challenge. Indeed, when radical surgery is not recommended and/or the tumor is technically unresectable, RT can be an option, but it often worries the radiation oncologists because of the proximity to high radiosensitive surroundings tissues, such as the bowel. Considering the previously delivered dose to the bowel and the severe toxicity which might result, if the cumulative dose exceeded the tolerance dose, in a risk/benefit ratio, the prescription dose of re-RT can achieve only a palliative aim, despite the highly conformal dose distribution of the modern RT techniques (such as stereotactic body RT [SBRT]; intensity-modulated RT [IMRT]; volumetric modulated arc therapy [VMAT]) [1]. However, for their intrinsic spatial

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Table 1
Synthetic spacer versus omentum flap: pros and cons.

	Pros	Cons
Synthetic spacer	Always available Clearly visible on imaging	Relatively biocompatible Not usable in a contaminated operating field Extraneous body effect Not always easy to place
Omentum flap	Totally biocompatible Extremely versatile in adapting to anatomical spaces and recesses Applicable in contaminated operating fields	Not always available for anatomical reasons or previous removal Risk of ischemia/torsion

selectivity, particles can overcome this drawback. Notably, carbon ion therapy (CIRT) is now a promising radiation technique due to its higher relative biological effectiveness (RBE) compared to photons. Moreover, the Bragg peak of carbon ions leads to a distal tail-off and a sharp lateral penumbra that increases the dose to the target minimizing the improper dose to the normal surrounding tissues [2].

Anatomical spacer insertion has been proved to be an effective and safe procedure before conventional RT [3] as well as hadrontherapy [3–7] to out distance the organs at risk, increasing the delivered dose to the tumor. Recent literature has described surgical procedures of silicon spacer placement before CIRT for several tumors, including sacral chordoma [4].

To the best of our knowledge, there is no report about the surgical techniques of the placement of omentum spacer prior to CIRT for gynecological recurrences in-field or at the edge of previous photon beam RT. The present note aims to describe our surgical approach, also highlighting the dosimetric advantages of such a tailored pelvic surgery.

2. Surgical procedure

In our clinical practice, the criteria of re-irradiation with CIRT of unresectable pelvic recurrences from gynecological malignancy stand as follows:

- at least 6 months from the end of the previous RT;
- only one recurrence within or at the edge of the previously irradiated field;
- the presence of a minimum distance between bowel and tumor of at least 5 mm measured by CT scan and MRI;
- unresectability surgical judgment.

When the distance between tumor and nearest intestinal tract is less than 5 mm, the opportunity of spacer insertion is discussed during the multidisciplinary tumor board and then with patients that are clinically evaluated jointly by a radiation oncologist (expert in the field of particle therapy) and a general surgeon (expert in the field of oncological surgery). The recommended spacer, whenever possible, is made by an omentum flap. In case of the absence of the omental flap (i.e. in very thin patients without peritoneal fat or in patients in whom the omentum has been removed in previous operations), the second choice is the synthetic spacer . Table 1 summarizes the pros and cons of the synthetic and omental spacer. The surgical procedure includes:

- patients decubitus in dorsal position with arms close to their body;

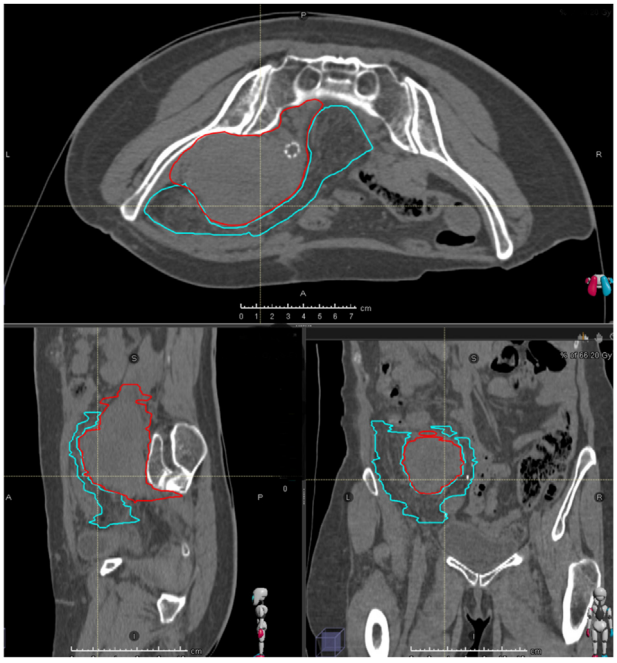

Fig. 1. The flap (light blue) into the pelvis covers the tumor (red).

- Trendelenburg position to displace bowel loops;
- general anesthesia with tracheal intubation;
- indwelling bladder catheter;
- during anaesthesia induction, a prophylactic intravenous antibiotic (with the first-generation cephalosporin according to the standard protocol of the surgery unit).

Considering the previous treatments (RT with or without surgery), and the resulting surgical adhesions, surgery is performed by laparotomic procedure: patients undergo an umbilical/pubic midline laparotomy (LPT) with direct access to the abdominal cavity. The first step is identifying the neoplasia and isolating it from the intestine with the exposure of the surface in contact with the small and large bowel. Once the omentum is isolated from possible adhesions, a flap is created in order to reach the pelvic area. The flap is made from the left to the right, keeping the gastroepiploic vessels that guarantee the vascularization of the flap. Then, the omentum is mobilized from the transverse colon and greater curvature of the stomach [8]. The flap is rotated into the pelvis to cover the tumor and fastened to ensure adequate fixation and stability. The pelvic placement should achieve avoiding the torsion of the pedicle that can lead to the omentum and bowel loops narrowing and ischemic injury. If, during the surgery, the bowel close to the tumor is infiltrated, a resection of the involved loop is mandatory to warranty the following safe CIRT. In this case, a terminal colostomy must be tailored. The abdomen is then closed as usual. The planning CIRT procedures usually start two weeks after the surgery.

3. Clinical example

To show the effect of the omentum spacer insertion on CIRT planning, we selected one of the cases of re-irradiation with CIRT of a recurrent endometrial cancer that underwent a prophylactic insertion of omentum flap as a spacer (Fig. 1). On the pre-surgery CT scan (applying the same dose constraints for organs at risk used in the delivered plan) we calculated a new plan that was compared with the plan effectively delivered to the patient after prophylactic surgery. Considering the previous dose delivered for photon beam

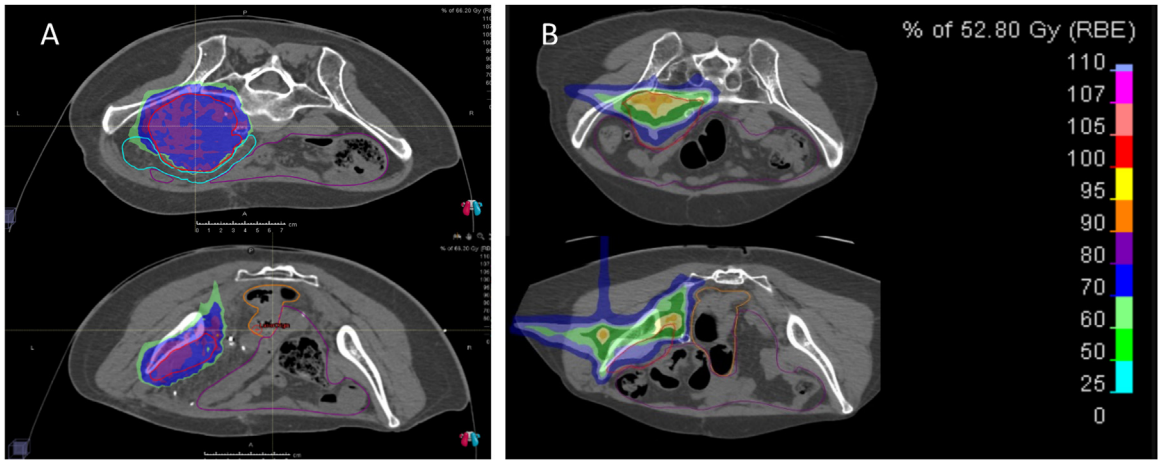

Fig. 2. (A) Delivered CIRT plan after spacer placement and (B) recalculated CIRT plan for the same recurrent endometrial patient without spacer insertion. In B the digestive tract is close to the target and, considering the dose constraints required to deliver a safe re-irradiation (in order to spare the bowel and the sigmoid/rectum), the coverage of the tumor is lower (D95 = 7 GyE) compared to the CIRT plan delivered after spacer insertion (D95 = 43 GyE). Between the staging CT and the planning CT (1 month), the tumor advanced locally, but the omentum flap allows to protect the bowel increasing the dose to the target volume.

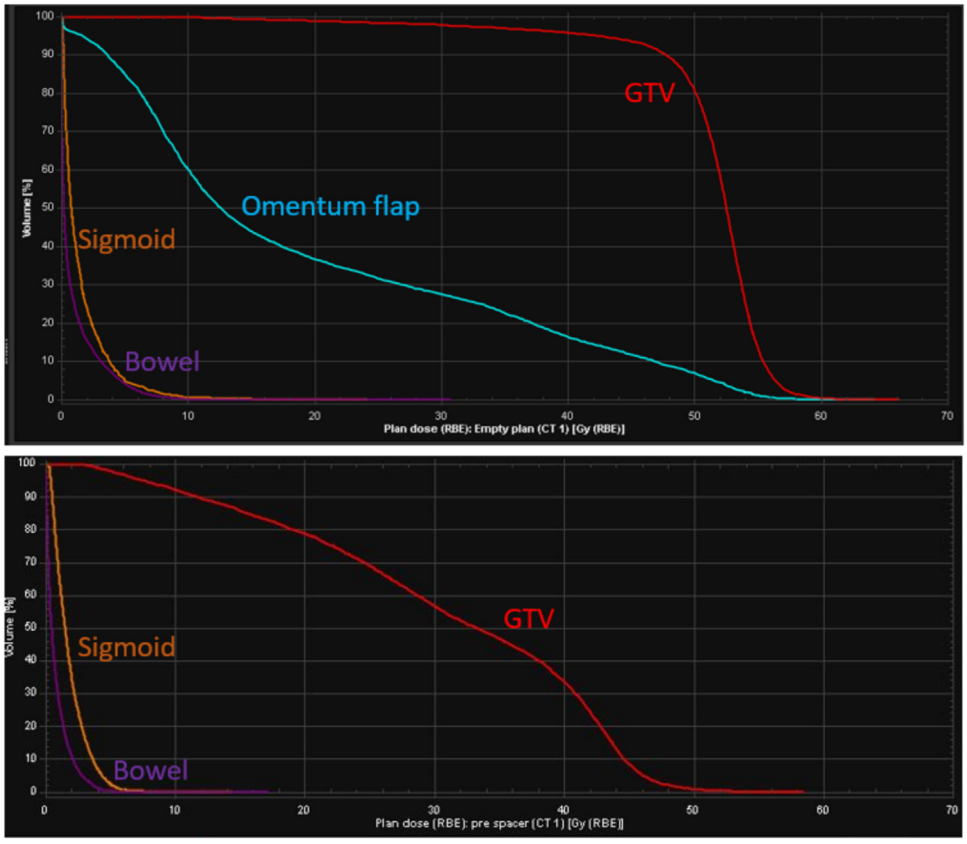

Fig. 3. Comparison of DVH for gross tumor volume (GTV) and digestive tract (bowel and sigmoid); coverage of the GTV is higher with the spacer (upper panel) compared to the plan without it (lower panel) respecting the dose constraints to the already irradiated pelvic organs.

RT (total dose: 50.4 Gy over 28 fractions), the prescription dose for CIRT was 52.8 GyE (over 12 fractions delivered in 3 weeks) using intensity-modulated particle therapy (IMPT) by two fixed fields (vertical and a left side lateral). As shown in the representative CT slices (Fig. 2A and B), the omentum provides a separation of the small bowel from the irradiated area, allowing an increase of tumor coverage and avoiding that the end of the spread-out Bragg peak (high LET region), generated by the beams, goes next to the organ at risk. The comparison between the dose-volume histograms (DVH) highlights the better coverage of the target due to the presence of the spacer (Fig. 3).

4. Discussion

Endometrial and cervical cancer mainly recur in pelvis [9,10], while pelvic relapses or relapses at a distance are rare for vulvar [11,12] and vaginal cancers [13,14]. Pelvic recurrence in-field or at the edge of a previous RT field is a challenge for

radiation oncologists. Indeed, considering the previously delivered doses to the normal surrounding tissues, often a curative prescription dose is not safely recommended. The literature reported several RT techniques for re-irradiation, such as intraoperative RT, SBRT, brachytherapy and particle therapy. Each one of these above-mentioned techniques is not free of late side effects. In fact, intraoperative RT literature reported a 1-year local control of 58% with 15–30% of grade 2–3 toxicities (neuropathy, urethral obstruction, and gastrointestinal adverse events) [15]. Otherwise, the steep fall-off of the brachytherapy doses, as well as the high conformal dose of the interstitial approach, reaches a 2-year local control of around 50%, with a high rate of G2-3 toxicities [15].

Moreover, also SBRT and particle RT dose prescription is strongly influenced by the previous course of RT. Shiba et al. [16] reported promising results in terms of local control (3-year local control: 74%) and toxicity rates (none grade 1 or higher acute toxicities nor Grade 3 or higher late toxicities) on sixteen cases of nodal recurrence of gynecological tumors re-irradiate with CIRT for a total dose of 48–57.6 GyE in 12 or 16 fractions. These encouraging results are related to the ballistic advantages of CIRT in the re-irradiation settings but also to its radiobiological characteristics. Indeed, a recurrence after RT is basically oxygen-poor and radioresistant. Carbon ions have proved to be independent on oxygen-effect and cell cycle phases [17] providing, compared to photons, an increased RBE, which may be estimated amid 2 and 5 [2]. Despite these great biological hallmarks, indisputably, the most significant concern regarding the application of CIRT for pelvic re-irradiation is intestinal and urinary toxicity. The close proximity between the bowel as well as the urinary tract to the target coerces the radiation oncologist to decrease the tumor coverage, shifting a curative treatment into a palliative one in order to reduce toxicity [18]. At our Institutions, the prophylactic surgery with omentum placement pre-CIRT is also tested for non-gynecological malignancies grown in a previous RT field with no reported intra-surgery toxicity [19]. Considering the curative option of re-irradiation in oligometastatic patients and the potential role of the particles in gynecological cancers, we believe that, in a tailored oncological perspective, the positioning of an omentum spacer can represent a solution to deliver safe high-dose CIRT for gynecological recurrences. Compared to the other type of spacer (synthetic or bioprosthetic) omentum is “natural”, less subject to post-surgical complications (such as infection, allergy or rejection) and ideal also in case of contaminated fields. The risk of ischemia of the epiploon represents a possible complication.

5. Conclusions

The prophylactic procedure of placement the omentum flap as a spacer before a re-irradiation with CIRT is an example of a multidisciplinary approach that tries to answer an unmet medical need. Modelling the spacer on the anatomical feature of the gynaecological patients allows for sewing a patient-tailored device. The use of omentum, instead of a synthetic spacer, might reduce the post-surgical complications. A multidisciplinary approach with a joint decision-making, based on outcome and patient-focused evaluation, is crucial to managing these difficult-to-cure patients awaiting a higher level of evidence.

CRediT author statement

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Disclosure of interest

The authors declare that they have nocompeting interest.

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