

Preoperative assessment of rectal cancer: an accurate MRI protocol a radiological template

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Learning objectives

The aims of our poster are:

- to review the MRI technique and protocol in preoperative local staging of rectal cancer (RC);
- to identify radiological signs that are useful for both the clinician and the surgeon;
- to provide some "tips & tricks" in the radiological evaluation of MR images in RC staging.

Background

Colorectal cancers are the second most frequent tumours in Western countries, particularly 1/3 of these cancers are localized in the rectum.

Surgery provides a wide range, from the trans-anal resection to multiorgan excision, remains the best therapeutic choice. However, nowadays, the concept of "mesorectal excision" is widely accepted among surgeons being supported by a low risk of local recurrence and a good compliance by patients. Hence, the need for a multidisciplinary approach, which includes oncologists, surgeons, radiologists and radiotherapists, each playing a key role in the management of patients with RC.

MRI is a valuable diagnostic tool to carry out a correct preoperative local staging of the disease and identify patients in need of a chemoradiotherapy (CRT) adjuvant preoperative or even identify cases where this proves simply a therapeutic overtreatment.

Partly following the numerous scientific guidelines on the MR-staging of the CR and supported by our personal and validated daily experiences , we aim to offer readers "an accurate MRI protocol and a radiological template".

Findings and procedure details

Our educational exhibit focuses exclusively on the preoperative evaluation of patients with CR. However, the MRI protocol described below is applicable both in the first staging

and in the restaging after adjuvant chemoradiotherapy, but MRI parameters useful in this latter situation will not be described.

PATIENT PREPARATION

- Although some guidelines do not recommend routine endorectal filling, we recommend a rectal relaxation through about 60-100 ml of a semiliquid solution containing ultrasound gel and water, administered by endorectal small cannula.

TIPS & TRICKS: you should advise patients to make two small evacuation enemas (e.g. through glycerine), respectively the night before and the morning of the MRI examination; you should not stretch too much the rectal ampulla since it could distort the morphology of the tumor, smashing it too much on the rectal wall and in rare cases you will make a compressive effect on mesorectal fat.

- Administration of a spasmolytic agent before image acquisition to reduce bowel motion artifacts.

TIPS & TRICKS: if you made rectal distension, the spasmolytic agent helps the patient to maintain continence during MRI examination.

MRI ACQUISITION PROTOCOL:

- Use of high field MRI equipment (at least 1.5 Tesla MR scanner).
- Use phased array surface coil; endorectal coil is not recommended, especially in patients with stenosing tumor.
- Patient in the supine position.
- Average MR duration: about 30 minutes.

Below the MRI sequences we use in our clinical practice, listed in temporal order; however are dutiful some premises:

- except for some post-contrastographic imaging and functional studies (DWI and Dynamic Contrast-Enhanced-DCE), in the morphological evaluation of the CR by sequences turbo spin echo (TSE) sequences, must **not be used** fat suppressed sequences (FAT-SAT);
- slice thickness must be in a range of about 1-4 mm;

MR images acquisition includes sequences acquired before and after contrast medium injection:

- PRE-CONTRASTOGRAPHIC SEQUENCES

1. sagittal TSE-T2 weighted: it **must** be the first acquired sequence: it will constitute a reference for the following axial and coronal oblique images (see below);
2. axial TSE-T2 weighted: includes the whole pelvis; it shows a panoramic view of the lower abdomen, including the tumor, extramesorectal and any peritoneal nodes;
3. axial TSE- T1 weighted: same as above but T1 weighted;
4. DWI free-breathing technique and multi b-values (0, 500, 1000 s/mm²) in the axial plane: quantitative and qualitative evaluation of the tumor.

The hyperintense signal in DWI reflects a high tumor cellularity, intratumoral edema and any possible intralesional cystic component, which is typical in the mucinous variant of the CR (Fig.3-left). Moreover, it allows calculating ADC values which are predictive of a possible neoadjuvant therapy success. Many studies, indeed, have shown that some CR with low-baseline pretreatment ADC values responded better to chemotherapy or radiation treatment than tumors with high-pretreatment ADC values. However, there is not any standardized cut-off value.

TIPS & TRICKS: DWI allows better visualizing even small tumors and identifying, but not characterizing, peritumoral nodes. The use of high b-values (e.g. 1000 s/mm²) eliminates the high signal due to the ultrasound gel used for endorectal filling, showing only the restriction in the signal of the tumor. You should calculate ADC values not just on a small tumor volume, but on a wide area (ROI) manually drawn that includes the tumor itself, thus increasing the diagnostic accuracy.

5. oblique axial plane High resolution (HR) TSE T2 weighted: using as reference image of the TSE-T2 weighted image in the sagittal plane, you have to consider a plane which is perpendicular to the major axis of the tumor. This is the key sequences of the whole MRI protocol: since it defines the exact relationship of the tumor to the mesorectal fat and mesorectal fascia.

TIPS & TRICKS: pretend to have images free from motion artifacts. If tumor is very wide in length with a curved major axis, you have to make a second acquisition using a perpendicular plane which is slightly modified, and then choose which one best describes the relationship with the mesorectal fascia.

6. coronal oblique HR TSE T2 weighted: using as reference image sagittal T2 weighted sequence, you have to create a plane which is parallel to the anal canal. This sequence is useful in evaluation of sphincter involvement in "low" RC.

TIPS & TRICKS: these two sequences (axial and coronal oblique) are acquired using a narrow (16 cm) Field of View (FOV) targeted exclusively to mesorectal region. In axial and coronal oblique sequences we do not use pre-saturation bands

- POST-CONTRASTOGRAPHIC SEQUENCES

1. DCE-MRI Fat-sat in the axial plane: the perfusion studies allow estimating tumor neoangiogenesis and predicting response to chemotherapy. Furthermore, together with DWI sequences, they allow differential diagnosis, in the assessments after adjuvant therapy, including fibrosis and tumor recurrence.

TIPS & TRICKS: although not being standardized, we consider necessary to perform perfusion studies to best validate the technique trying to MR- staging not only through morphological parameters but also with functional ones. Considering that in the protocol intravenous contrast medium is injected it would be inappropriate if perfusion study were not performed.

2. axial and sagittal TSE T1 weighted: morphological post-contrastographic evaluation.

3. High-resolution volumetric 3D fat-sat T1 weighted: it provides an excellent post-contrast enhancement morphological evaluation of the tumor (Fig.2-right and Fig.3-right) and, in some cases, it is useful in identifying the venous peritumoral spreading.

IMAGES ANALYSIS

Here are parameters that should be evaluated and included in our suggested radiological template, reporting only "*WHAT surgeons, oncologist and radiotherapist WANT*"

1. Locate tumor: "*Where is the tumor?*"

- Measure the distance from the anal margin to lower border of the tumor:

- < 5cm: lower III of the rectum (low rectal);
- between 5-10cm: medium III of the rectum (mid rectal);
- > 10 cm: upper III of the rectum (high rectal);

TIPS & TRICKS: tumors of the upper rectum easily spread in the peritoneum; this latter covers only the anterior wall of the rectum. The tumors of the low rectum tend to recur more.

- Craniocaudal extension of the tumor (measured in centimetres).

- Distance between anal verge and upper border of the tumor.

2. Depth of invasion through the layers of the intestinal wall and in the surrounding Mesorectal fat: " What is the tumor spread?"

-T staging: the process of T-Staging is shown in the Table 1 and Fig.1.

MRI helps to distinguishing the different layers of the bowel: in T2 weighted images, the submucosa has an high signal intensity, the muscularis has a low signal intensity, while the perirectal fat has an high signal intensity and contains signal void vessels.

TIPS & TRICKS: Do this assessment just on HR T2 weighted sequences in the axial oblique plane (Fig. 2-left). T1 and T2 tumors can not be distinguished through MRI, endoanal ultrasound must be used in these cases. You will often find some difficulties in tumors with minimal mesorectal spread (T3a, T3b), because around the rectal wall there can be present a desmoplastic stromal reaction, which can be misinterpreted as tumor tissue. Hence, we advise to use these criteria: appearance with "spiculated" striae represents a desmoplastic fibrotic reaction, while the presence of "broad based" or nodular tissue permeating into the mesorectal fat and in continuity with the intramural portion of the tumor is indicative of neoplastic spread. Remember that the distinction between T2 and T3 with mesorectal invasion less than 5 mm (T3a and T3b) may be irrelevant, as these types of cancer may not benefit from some adjuvant chemoradiotherapy.

- Growth pattern: annular, polypoid , ulcerated , mixed.

- Sphincter staging : in cases of " low" rectal cancer it is useful to carry out a tumor staging considering the sphincter structures (see Table 2 and Fig.4). Use the coronal oblique plane HR T2 weighted sequences.

3. Involvement of mesorectal fascia: "What is the status of Mesorectal Fascia?"

- Evidence of direct infiltration of the mesorectal fascia by the tumor or nodes: yes or no

- Circumferential Resection Margin (CRM) status: shortest distance from the tumor in the mesorectal fat to the mesorectal fascia (measured in millimetres):

- > 1 mm: CRM negative
- < 1 mm: CRM positive

TIPS & TRICKS: the presence of a node distant less than 1 mm from the mesorectal fascia is predictive of infiltration (CRM positive; see later).

4. NODAL STATUS: " What is the nodal involvement?"

- **N-stage:** number of probably metastatic nodes within the mesorectal fat:

- N0: no nodes
- N1: 1-3 nodes
- N2: >4 nodes

Criteria of malignancy: size > 8 mm; round shape with a short axis diameter > 5 mm; irregularity of the surrounding capsule; irregular and spiculated borders; inhomogeneous intensity signal MRI (likely contain areas of necrosis or mucin); the presence of intranodal fat is not a typical feature of mesorectal nodes. Post-contrastographic enhancement is present in both hyperplastic and metastatic nodes.

- **Node at <1 mm** of distance from **mesorectal fascia:** CRM+

- **Extrameresorectal nodes:** located in the pelvis (iliac, obturator, etc)

TIPS & TRICKS: The nodal involvement is defined with certainty only through histopathology; MRI alone is not sufficient due to the presence (not uncommon) of micrometastases. Use caution in their assessment; remember that the nodal spread is one of the most important risk factors both for local and distant recurrence. The DWI evaluation does not increase the specificity. Both malignant and benign nodes shows high signal on DWI images. Use however this sequence to facilitate their detection (especially for small nodes). The ADC of metastatic nodes is usually lower, but it is not yet established a reference cut-off. Currently you can not use it as a diagnostic criterion.

5. Negative prognostic factors associated: *"There are more poor prognostic factors?"*

- Extramural vascular Invasion (EMVI): the presence of venous vascular spread is indicative of probable relapse and/or high malignancy. *Diagnostic criteria EMVI:* proximity between tumor and vascular structures; rounded edges of the vessels, swollen and widen appearance (presence of intraluminal tumor tissue, neoplastic thrombosis) and inhomogeneous signal intensity (reduced artefact flow void)

TIPS & TRICKS: do not confuse EMVI with peritumoral desmoplastic reaction (spiculated and thin appearance)

- Presence of intratumoral mucin pool: hyperintense foci on T2w sequences, indicative of mucin pool.

TIPS & TRICKS: The mucinous variant of CR is correlated with increased local recurrence, nodal and peritoneal spread. Intratumoral necrosis or abscesses can mimic mucin pool. Medium signal intensity in FatSat T2w images and intravenous administration

of gadolinium can help: in some cases, mucin shows a rise of intensity signal in post-contrastographic sequences.

- Pelvic secondary nodulations: peritoneal metastatic nodules, with spiculated and irregular margins that show inhomogeneous post-contrastographic enhancement (tumor like).

- Dynamic perfusional evaluation:

- *Wash-in and Wash-out curves*: in our experience the neoplastic tissue (compared to healthy rectal wall) has a significant and rapid wash-in with moderate plateau phase and/or mild wash-out.
- *K-trans*: the presence of high values of K-trans in the context of the tumor tissue, compared to normal rectal wall, is indicative of neoplasia.

TIPS & TRICKS: although still under study, perfusion imaging is used as tool for assessing angiogenesis and thus the possibility of CRT success. Rectal tumors with higher permeability at presentation appear to respond better to CRT than those of lower permeability. Ongoing studies are evaluating its usefulness in the response to neoadjuvant treatment (in combination with assessment DWI) with the ability to discriminate the residual tumor from fibrosis.

Images for this section:

Tx	primary tumour cannot be assessed
T0	no evidence of primary tumour
T1	tumour invades submucosa
T2	tumour invades but does not penetrate muscularis propria
T3	tumour invades mesorectal fat through the muscularis propria
<i>T3a</i>	tumour extends <1 mm beyond muscularis propria
<i>T3b</i>	tumour extends 1 - 5 mm beyond muscularis propria
<i>T3c</i>	tumour extends 5-15 mm beyond muscularis propria
<i>T3d</i>	tumour extends >15 mm beyond muscularis propria
T4	tumour invades directly into other organs or structures

Table 1: T-Staging

STAGE 1	Tumor confined to bowel wall but does not extend through full thickness; intact outer muscle coat
STAGE 2	Tumor replaces muscle coat but does not extend into intersphincteric plane
STAGE 3	Tumor invades intersphincteric plane or lies within 1 mm of levator muscle
STAGE 4	Tumor invades external anal sphincter and is within 1 mm and beyond levator with or without invading adjacent organs

Table 2: Sphincter Staging (for "low" rectal cancer)

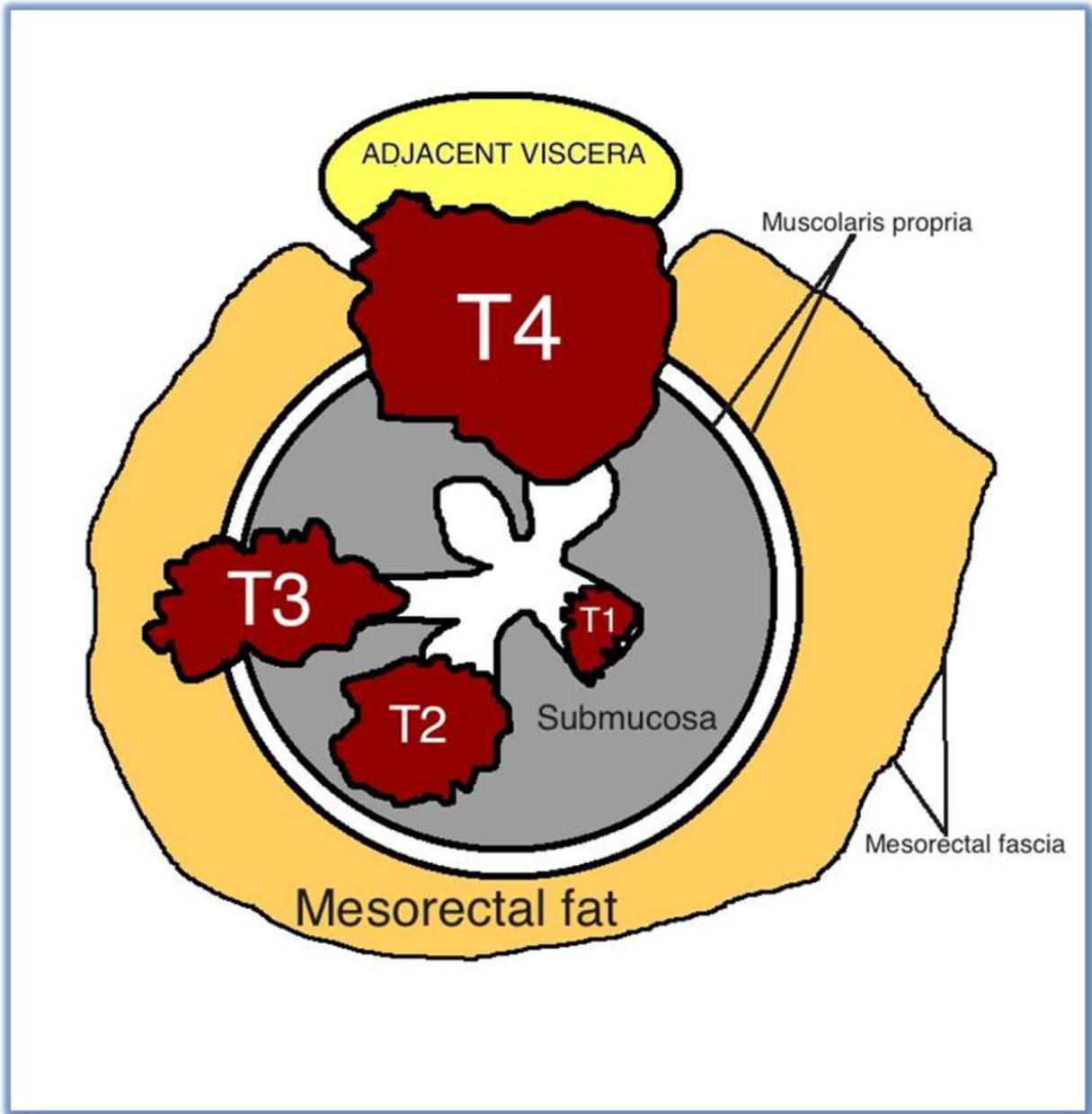


Fig. 1: T-Staging



Fig. 2: MRI study shows mid-rectal cancer, mesorectal spread(T3), inhomogeneous contrast enhancement and moderate vascular spreading.

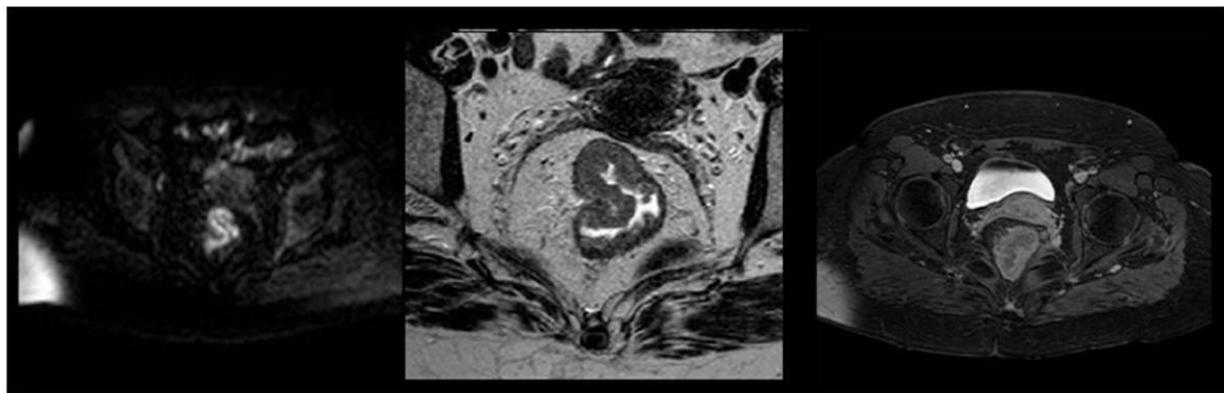


Fig. 3: MRI study shows mid-Low rectal cancer with inhomogeneous contrast enhancement, vascular spreading, high restriction in DWI sequence and presence of metastatic lymph node close to mesorectal fascia.

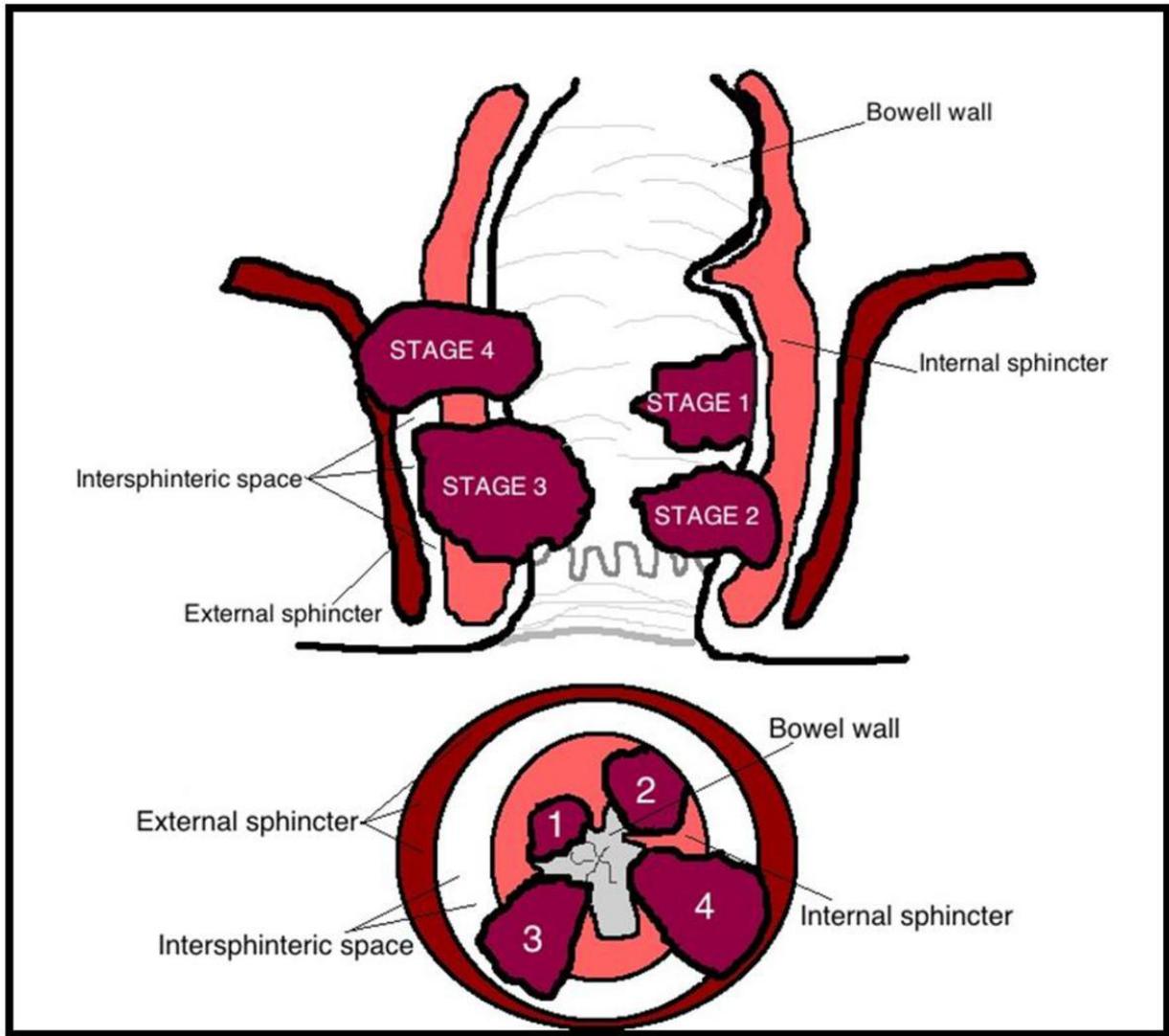


Fig. 4: Sfinterial Staging

Conclusion

Local staging of rectal cancer through MRI plays a key role in patient's therapeutic management, reducing the risk for local recurrence or distal spread and helps to preoperatively identify valuable prognostic information. MRI report must be focused to provide clear, detailed and above all "necessary" data to the multi-disciplinary team (oncologist, radiotherapist, surgeons) involved in the management of the patient. Each of them would love to get from radiologist comprehensive and exhaustive local staging in order to draw up a proper therapeutic planning of each patient with RC.

Personal information

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