Intraoperative MRI Features of Absorbable Oxidized Regenerated Cellulose During Cerebral Glioma Surgery

Características de imagens de ressonância magnética intraoperatória da celulose regenerada oxidada absorvível durante cirurgia para gliomas cerebrais

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ABSTRACT

Objectives: Foreign body reaction to absorbable hemostatic agents may mimic recurrent brain tumor or abscess on postoperative MRI. Their appearance on intraoperative MRI and their use as resection borders marker have been not previously described. This study evaluates the intraoperative MRI appearance of absorbable oxidized regenerated cellulose in surgery of cerebral gliomas.

Methods: 72 patients with cerebral gliomas were intraoperatively examined with high field MRI (1.5 T). 32 patients presented low-grade and 40 high-grade gliomas. After tumor resection the tumor bed was covered with absorbable oxidized regenerated cellulose.

Results: The absorbable hemostat presented a hyperintense signal on MRI-T1 sequences in all patients. Tumor remnants under the hemostatic agent could be identified.

Conclusions: Oxidized Regenerated Cellulose can be easily observed as a hyperintense signal lining covering the borders of the surgical cavity on intraoperative MRI-T1 sequences. It may be a useful marker of tumor resection borders of cerebral gliomas.

Keywords: intraoperative MRI, oxidized regenerated cellulose, glioma, surgery, resection border marker

RESUMO


Métodos: 72 pacientes com gliomas cerebrais foram examinados com RM intraoperatória de alto campo (1,5 T). 32 apresentavam gliomas de baixo grau e 40 de alto grau. Após ressecção da lesão o leito tumoral foi revestido com o agente hemostático.

Resultados: Celulose regenerada oxidada absorvível apresentou sinal hiperintenso na sequência T1 em todos os pacientes o que ajudou na identificação de tumor residual sob o plano do agente hemostático.

Conclusões: Na sequência T1 da RM intraoperatória a celulose regenerada oxidada absorvível apresenta sinal hiperintenso que pode ser um marcador útil para delimitar os bordos de resecção tumoral.

Palavras-chave: ressonância magnética intraoperatória, celulose regenerada oxidada absorvível, glioma, cirurgia, bordos de ressecção
INTRODUCTION

Hemostatic agents have been used since many years in different surgical procedures \(^{4,6,11}\). In the 1940s gelatin sponge or Gelfoam® (Pfizer Inc, New York – USA) was first introduced in neurosurgery. Surgicel® (Johnson & Johnson Medical - Brazil), an absorbable oxidized regenerated cellulose derived from alpha-cellulose, is widely used as hemostatic agent in neurosurgery. It works in the intrinsic pathway of clotting causing contact activation and has a relative antibacterial activity when compared to Gelfoam® and topical thrombin. \(^3\) It is bio-absorbable and may be left in the surgical bed. Its postoperative appearances were studied with X-rays, ultrasonographic studies and CT-scan \(^{9,16,17}\). Early in the postoperative period Surgicel® may mimic an abscess on both MRI and sonography \(^{10}\). There are very few reports on the appearance of Surgicel® on postoperative magnetic resonance imaging (MRI) in neurosurgery \(^{10,15}\). In the last years intraoperative MRI has become the golden standard in surgery of cerebral gliomas \(^{12}\). This method increases the possibility of radical removal and safety in surgery of these lesions. The objectives of our study were to describe the appearance of Surgicel® on intraoperative MRI and its use as marker of resection borders during the surgery. There is no report in the literature describing the features of Surgicel® on intraoperative MRI during neurosurgical procedures.

MATERIAL AND METHODS

This prospective study evaluates the appearance and the reliability of using Surgicel® as marker of resection borders during intraoperative MRI in a series of 72 patients operated on cerebral gliomas. Thirty-two patients presented low-grade gliomas and 40 patients high-grade gliomas. After tumor resection careful hemostasis was performed and Surgicel® was placed covering the entire tumor bed in a monolayer fashion. Intraoperative high field MRI (1.5 T, GE-Excite, USA) was performed. Our protocol studied the following MRI sequences: a) Low-grade non-enhancing gliomas: T1, T2, T2-SWI (Susceptibility Weighted Imaging) and FLAIR (Fast fluid-attenuated inversion-recovery) with no gadolinium injection. All intraoperative MR examinations were followed by the surgeons and neuroradiologists. Characteristics of Surgicel® on MRI and the validity of its use as marker of tumor resection borders showing eventually residual lesion under the monolayer of Surgicel® were registered.

RESULTS

Studying 72 operated cerebral gliomas we have observed that Surgicel® presented a hyperintense signal in T1 contrasting with the very thin hypointense signal over the tumor resection bed observed during intraoperative MRI (Figure 1). Sequences T2, SWI and FLAIR with or with no gadolinium injection could not clearly define the Surgicel® layer. Figure 2 shows a comparison of the studied MRI sequences. The T1 sequence without gadolinium injection was the best sequence to delineate the monolayer of Surgicel®. In this series Surgicel® used as marker of tumor resection borders was useful during removal of high-grade gliomas (Figure 3) as well as of low-grade gliomas (Figure 4). Twenty-three patients (33%) underwent additional tumor removal after intraoperative MRI.
Figure 1: Right frontal lobe low-grade glioma. A- Intraoperative MRI-T1 with gadolinium (axial plane) showing the hyperintense signal of surgical layer (arrows) as marker of resection borders. Residual tumor can be observed under the surgical layer (arrow heads). B- Intraoperative T2 without gadolinium. The hemostatic layer is not well demonstrated. Residual tumor (arrow heads). C- Intraoperative MRI-T1 with gadolinium (sagittal plane) showing clearly the surgical layer (arrows) and residual tumor (arrow head).

Figure 2: Intraoperative MRI during removal of a right parietal glioblastoma. A- T1 without gadolinium demonstrating clearly the surgical layer as marker of resection borders (arrows). B- T2 sequence, the surgical layer is not well defined. C- T2 SWI sequence, artifact produced by air bubbles and blood (“blooming artifact”) does not allow visualization of the surgical layer.

Figure 3: A- MRI – T1 with gadolinium showing a left frontal glioblastoma. B & C- Intraoperative MRI-T1 with gadolinium demonstrating the hyperintense signal of surgical as marker of resection borders (arrows).

Figure 4: A- Intraoperative MRI-T1 after radical resection of a left frontal (supplementary motor area) low-grade glioma. The resection borders are well demarcated with surgical layer (arrows). B- MRI-T1 performed 24 hs after the surgical procedure showing the resection cavity filled with hyperintense material.

Discussion

Topical hemostatic agents are often used to achieve and to maintain hemostasis in surgical fields. Surgicel®, an oxidized regenerated cellulose, is one of the most used hemostatic...
agents in neurosurgery due to its hemostatic and proven bactericidal properties against a broad range of gram-positive and gram-negative organisms1,3,14. It has a relatively low pH which causes some small vessel contraction and inflammatory reaction. Damage to the endothelium exposes collagen causing platelet aggregation and adhesion. Surgicel® may promote a foreign body reaction and a granuloma formation as result of inflammatory reaction and macrophages action. These reactions to Surgicel® may mimicking a tumor recurrence or brain abscess in imaging studies2,7. Grade of tumor resection has been demonstrated to be one of the most important prognostic factors in outcome of patients harboring low-grade or high-grade gliomas8,13. Intraoperative MRI has become the most valuable tool to assure intraoperatively the extension of tumor removal in cerebral glioma patients10. Tumor volume resection is usually better evaluated in T1 sequence with gadolinium enhanced tumors and FLAIR and T2 with gadolinium non-enhanced lesions. A marker showing tumor resection borders during intraoperative MRI helps the evaluation of the extent of tumor removal in both groups of patients. The appearance of Surgicel® on the intraoperative MRI was of a lining with hyperintense signal in T1 sequence covering the entire surgical field. This finding was constant in all patients of this series and could help to identify tumor remnants under the hemostatic agent layer. The postoperative MRI, 24hs after the procedure, showed hypointense signal within the resection cavity and the Surgicel® layer could not be so well observed as during the intraoperative MRI (Figure 3 B). T2-SWI MRI sequences usually can show very well hemoglobin degradation products, but during surgery the presence of air bubbles and blood within the surgical cavity may produce a “blooming” artifact and the Surgicel® layer will not be well delineated (Figure 4 C). Spiller et al have demonstrated that Surgicel® in vitro presented a hyperintense signal in MRI-T1 sequence15. According to these authors this hemostatic agent accelerates the oxidation of oxihemoglobin to metahemoglobin that is paramagnetic and has a hyperintense signal in T1 sequences. The appearance of Surgicel® in the resection borders of cerebral gliomas in T1-MRI is of a hyperintense layer. This hemostatic agent accelerates the oxidation of oxihemoglobin to metahemoglobin that is paramagnetic and has a hyperintense signal in MRI-T1 sequences. This layer of Surgicel® may be a useful marker of tumor resection borders in cerebral glioma surgery.

CONCLUSION

The appearance of Surgicel® in the resection borders of cerebral gliomas in T1-MRI is of a hyperintense layer. This hemostatic agent accelerates the oxidation of oxihemoglobin to metahemoglobin that is paramagnetic and has a hyperintense signal in MRI-T1 sequences. This layer of Surgicel® may be a useful marker of tumor resection borders in cerebral glioma surgery.

REFERENCES


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