Prostatic carcinoma (PC) treated with focal cryosurgical ablation (FCA): Magnetic resonance (MR) imaging patterns

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Learning objectives

To report the spectrum of MR findings of prostate gland treated with focal cryotherapy.

To show the evolution, as time passed, of the signal intensities of prostatic lesions treated with focal cryotherapy.

To illustrate the most significant MR criteria of appropriate treatment of prostatic neoplasms by focal cryotherapy.
Background

Although prostate cancer has been considered a heterogeneous, multifocal disease requiring whole-gland therapy, recent studies demonstrated that a proportion of cancers are unifocal, unilateral or of lower malignant potential. In the decade from 1990 to 2000, prevalence of low-risk prostate cancers has increased from 30 to 45%, and focal therapy for prostate cancer is emerging as a desirable and feasible approach for low-risk, localized disease (1).

The essence of focal therapy is precise targeted ablation of a small tumors, preferably minimally invasively, while preserving the remainder of the uninvolved organ (1).

The standard treatment options for localized prostate cancer are radical prostatectomy, external-beam conformal radiotherapy, brachytherapy and watchful waiting (1).

Cryosurgery is an alternative therapy for the treatment of localized prostate cancer that provides some advantages over the conventional treatments (low morbidity rate, shorter hospital stay, negligible blood loss, less expensive than competing therapies) (2).

Recently, some authors published clinical studies of focal cryoablation in the treatment of select patients with low-to-moderate risk prostate cancer as a possible alternative to whole-gland treatment (3,4).

The soft-tissue contrast resolution and multiplanar imaging capability of MR provide an effective tool for imaging follow-up of neoplastic lesions treated with cryoablation technique (5,6,7,8).

In this study we report the spectrum of MR findings of prostate gland treated with focal cryotherapy.
MATERIALS AND METHODS

4 patients with prostatic carcinoma underwent focal cryosurgical ablation.
All cryoablation procedures were performed using 4 cryoprobes (SeedNet, Galil Medical) (Fig. 1 on page 6). The patients were treated with hemiablation (the freezing zone enclosed half of the prostate parenchima with a margin of about 1 cm, taking care of the periurethral zone in order to spare the urethra). Ablation zone is extended to include ipsilateral neurovascular bundle and margin (treatment of possible extracapsular extension of disease) (Fig. 2 on page 6).
Patients were followed up clinically, biochemically (PSA) and by MR imaging 24 hours after surgery, and subsequently at 3 and 12 months.
All examinations were performed with a 1.5T MR system (Philips Gyroscan Intera Power) using the body phased-array coil. Imaging protocol included axial Gradient Echo (GRE) T1w, Turbo Spin Echo (TSE) T2w sequences and contrast-enhanced (ce) TSE fat-suppressed (FS) T1w sequence. TSE T2w and ce TSE T1w images were also obtained in the sagittal plane. Post contrast TSE FS-T1w images were also evaluated before and after digital subtraction procedure.
We evaluated the following parameters: A. Morphology of the gland; B. Signal intensity of the treated areas; C. Patterns of vascularization of the treated areas.

IMAGING FINDINGS

SIGNAL INTENSITY

24 hours after cryoablation, T2w images showed the prostate parenchima heterogeneously iso-hyperintense, without significative differences in terms of signal intensity between the treated and the spared zone of the gland. The margins of the gland resulted poorly defined, without perilesional rim (Fig. 3 on page 7, Fig. 4 on page 8, Fig. 5 on page 9).
At 3 and 12 months follow-up treated tissue showed high signal intensity on T2w images, with a sharp hypointense perilesional rim (Fig. 3 on page 7). All the patients showed persistence of isointensity of the spared prostatic tissue. The margins of the gland in correspondence of the treated areas resulted well defined (Fig. 3 on page 7).

SIZE

24 hours after treatment the treated gland were more than 6 mm larger than the original gland (Fig. 3 on page 7, Fig. 4 on page 8, Fig. 5 on page 9). MR examinations showed a mean decrease in size of the treated areas of 30% at 3 months and 70% at 12 months following cryoablation (Fig. 3 on page 7).
The size of prostate gland treated with cryotherapy was better evaluated on TSE T2w and subtracted ce-FS GRE T1w images.

VASCULARIZATION

Post treatment ce-FS T1w and subtracted MR images showed ischemia of the treated zone of the gland, with hypointensity compared with normal prostatic parenchyma, and relative enhancement of the untreated gland (Fig. 3 on page 7, Fig. 4 on page 8, Fig. 5 on page 9, Fig. 6 on page 10).
CLINICAL FOLLOW-UP
All the patients had a stable PSA level (range 0.2-1.4 ng/mL) at 12 months after the treatment.
No patients had clinically documented urinary complications related to the procedure.
MR imaging follow-up revealed no evidence of distant recurrence in all the patients.
**Images for this section:**

![Cryoprobes and cryoablation procedure of a prostatic carcinoma](image)

**Fig. 0:** FIG. 1 (Cryoprobes and cryoablation procedure of a prostatic carcinoma) (A) 17G cryoneedle. (B) scheme of cryoprobes placement into the prostate gland (C) 17G cryoneedles inserted through the perineum to outline the shape of the prostate

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Fig. 0: FIG. 2 (Focal cryoablation of a prostatic carcinoma) Scheme of prostate hemiablation. Ablation zone is extended to include ipsilateral neurovascular bundle and margin (treatment of possible extracapsular extension of disease)

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**Fig. 0:** FIG. 3 (73-year-old man who underwent cryoablation for prostatic carcinoma)

On T2w images, treated prostate was heterogeneously iso-hyperintense 24 hrs after treatment. Cryolesion resulted hyperintense, with hypointense perilesional rim, at 3 and 12 months after treatment, with isointensity of the spared zone of the gland. 24 hrs after treatment, the prostate was about 1 cm larger than the original gland; progressive decrease in size at 3 and 12 months after surgery.

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**Fig. 0:** FIG. 4 (75-year-old man who underwent cryoablation for prostatic carcinoma)

On T2w images, treated prostate showed heterogeneous iso-hyperintensity 24 hrs after treatment. Conventional and subtracted ce-T1w MR images showed ischemia of the left portion of gland, and relative enhancement of the periurethral zone and contralateral portion of the prostate (arrows).

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**Fig. 0**: FIG. 5 (78-year-old man who underwent cryoablation for prostatic carcinoma) 24 hrs after treatment, prostate was more than 10 mm larger than the original gland. Heterogeneous iso-hyperintensity of the prostate 24 hrs after treatment (arrow). Conventional and subtracted ce-T1w MR images showed ischemia of the treated area (arrows).

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**Fig. 0:** FIG. 6 (comparison between whole gland and focal cryoablation) MR images showed ischemia of the peripheral gland and relative enhancement of the central portion of the prostate, due to the sparing of the periurethral zone, in patient treated with whole gland cryoablation. Ischemia of the left portion of the gland, with relative enhancement of the spared zone of the gland, in patient treated with focal (left) cryoablation.

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Conclusion

DISCUSSION
Cryosurgery is the term used to describe tissue destruction using extreme cold temperature. The histologic sequelae of this process are inflammatory reaction, coagulative necrosis and finally fibrosis and scarring (9).
Focal cryoablation is an alternative therapy for the treatment of localized prostate cancer, that provides precise targeted ablation of small tumors, preserving the remainder of the uninvolved organ (3,4) (Fig. 6 on page ).
As it is not possible to document histopathologically the complete tissue necrosis after cryoablation and PSA level results variable and not completely useful in the follow-up, a radiological follow-up can be helpful (8).
Among the different imaging techniques, MRI represents the ideal one since it is reproducible, non operator dependent and optimally able to detect the difference of necrotic and still viable tissue. Nevertheless, usefulness of MR imaging follow-up of patients with prostate cancer treated with cryosurgery remains controversial (5,6,7,8).
In patients treated with focal cryoablation for localized prostate cancer, cryolesions typically appear to be hyperintense with a hypointense peripheral rim on T2w images, due to the coagulative necrosis induced by cryotherapy. The treated areas showed an increase in size 24 hours after treatment, due to postcryosurgery prostate edema, and a progressive decrease in size, due to fibrotic evolution of cryolesions. After hemiablation, prostate showed no significant vascularization of the treated zone, with sparing of the periuretral and controlateral zone, on ce-MR images, due to vasocostriction and thrombosis of distal arterioles and venules induced by cryotherapy.
In our study, according to previous MR imaging studies performed on patients treated with cryotherapy for small renal masses (10), the most significant MR patterns in the follow up of prostatic carcinoma treated with cryosurgical focal ablation were the decrease in size with the passing of time and the complete ischemia of the treated area of the prostate, with sparing of the periuretral and controlateral zone.
The most effective MR techniques for lesions size and enhancement evaluation were TSE T2w and subtracted ce-TSE-FS T1w sequences.
CONCLUSION
Focal cryosurgical ablation is a safe, well tolerated and minimally invasive therapy for localized prostatic carcinoma.
MR can be an effective imaging technique in the follow-up of prostate tumors treated with focal cryosurgical ablation, in particular in the early evaluation of the efficacy of the treatment (immediate feedback about size and geometry of the cryoinsult) and in the evaluation of patients with clinical or laboratory suspect of recurrence.
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