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Case Report

Real-time Doppler ultrasound to identify vessels and guide needle placement for gynecologic interstitial brachytherapy

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ABSTRACT

PURPOSE: Doppler ultrasound (US) gives real-time information regarding anatomy and blood vessel location to guide needle placement for gynecologic interstitial (IS) brachytherapy (BT). We retrospectively assessed Doppler US images for vessel quantity, size, and distribution in cervical cancer patients undergoing high-dose-rate BT at our institution.

METHODS AND MATERIALS: Eleven consecutive patients undergoing IS high-dose-rate BT implants for cervical cancer between 2015 and 2017 were included. Transrectal Doppler US was used for real-time image guidance. US images were retrospectively evaluated. Vessel quantity, size, and distribution at superior and inferior levels of the cervix were recorded. Correlation of vessel quantity with tumor size and International Federation of Gynecology and Obstetrics stage was evaluated.

RESULTS: Average vessel quantity was 4.2 in the inferior cervix and 3.8 in the superior cervix (range 1−11). Median vessel diameter was 2 mm in the inferior cervix and 2 mm in the superior cervix (range 1−6 mm). The most common location was posterolateral (3:00−5:00 and 7:00−9:00), outer third (78% of vessels inferiorly, 64% of vessels superiorly). Vessel quantity was correlated to initial tumor size superiorly ($p = 0.04$, paired t-test) but not inferiorly ($p = 0.31$, paired t-test). There was no correlation between vessel quantity and International Federation of Gynecology and Obstetrics stage ($p > 0.05$, analysis of variance). Doppler US was successfully used to guide needle placement away from visualized blood vessels with no incidents of hemorrhage in these patients.

CONCLUSIONS: Doppler US is a useful tool to guide needle placement for IS BT for cervical cancer. Vessel quantity varied with increased vessel quantity seen higher in the cervix for larger tumors. Vessels were most commonly distributed in the outer third of the posterolateral cervix.
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keywords: Cervical cancer; Brachytherapy; Image-guided; Doppler; Ultrasound

Introduction

Combined intracavitary/interstitial (IC/IS) applicators for gynecologic brachytherapy (BT) have consistently been associated with improved target coverage, decreased dose to organs at risk, and increased local control rates compared to patients treated with IC technique (1−5).

Hemorrhage into the peritoneal cavity or vagina during applicator placement or removal is an uncommon but potentially serious complication of IS BT for gynecologic cancers and may result from damage to blood vessels during needle insertion or removal. The bleeding risk in prior published series using IC/IS technique ranges from 0% to 4% (1, 4).

Although fluoroscopy, laparoscopy, and CT can be used to guide needle placement for IS implants, these modalities do not allow the real-time detection of vessels as the needle tips are guided into place (6−11). Transrectal ultrasound (TRUS) guidance, although widely used in prostate cancer, is less commonly used in gynecologic BT but allows real-time image guidance. The addition of Doppler technology enables detection of blood vessels as BT catheters are inserted, and needle tips can be guided accordingly. We have been using this function routinely since the adoption of TRUS probes that incorporates Doppler technology and

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have found it useful to guide needle placement away from larger vessels within the cervix.

We retrospectively evaluated Doppler US images to document common vessel distribution and size to inform future implants. This may lower the risk of bleeding complications during IS BT procedures.

Methods and materials

Consecutive cervical cancer patients undergoing BT as part of definitive chemoradiotherapy at our institution between 2015 and 2017 were included in this institutional review board-approved study.

BT technique

We use freehand TRUS-guided IS/IC BT technique for cervical cancer patients undergoing BT at our institution.

It is our policy to use at least two IS catheters in conjunction with the tandem and ring applicator to improve coverage of the high-risk clinical target volume (CTV) and lower dose to bladder and bowel. Under sedation and epidural anesthesia, a tandem is placed through the cervical os and secured into place with a stitch through the posterior cervical lip. Two IS catheters are then inserted into the cervix 1.0−1.5 cm laterally on either side of the uterine tandem and advanced under TRUS guidance. Additional parametrial or periurethral catheters may be inserted under US guidance at the discretion of the attending physician based on findings from the preimplant MRI scan and intraoperative US and physical findings. After our recent acquisition of a US with Doppler capability, we use the Doppler function to identify vessels and to provide real-time guidance for vessel avoidance during needle placement. A ring applicator and vaginal packing are subsequently inserted, and the entire apparatus consisting of a tandem, ring, and at least two IS catheters is secured together using dental putty. For patients with more advanced disease in which vaginal coverage is required, a cylinder with surface needles may be substituted for the ring.

Patients receive a dose of 2800 cGy in four fractions prescribed to the high-risk CTV over two implants 1 week apart, with two fractions per implant, after completing external beam radiotherapy with a dose of 45 Gy over 25 fractions. This corresponds to an EQD2 of 84.25 Gy, $\alpha/\beta = 10$.

US specifications

A Hitachi-Aloka Noblus LE model US was used with a 33 cm EUP-R54AW transrectal transducer. EZU-RA6 (version: V06-10 step3.1) software was used. A 360° field of view was used during the procedure with a frequency of 5 MHz to optimize vessel identification.

Image evaluation

US images of implants captured at the time of BT were evaluated. For the purposes of this study, images from a single implant for each patient were retrospectively evaluated. Transverse Doppler images were captured at two levels within the cervix, inferior and superior. Doppler was not used to evaluate vessel flow but rather only to identify vessel location. The number of vessels with diameter at least 1 mm was recorded for each patient. We documented vessel diameter and location, including axis as per clock face and depth within the cervix (inner, mid, or outer third).

Statistical analysis

Descriptive statistics were used to evaluate vessel quantity, size, and location. Tumor size and International Federation of Gynecology and Obstetrics T-stage were recorded for each patient. The correlation between tumor size and vessel quantity was evaluated with two-tailed paired *t*-test. Two-sided analysis of variance was used to determine correlation between T-stage and vessel quantity. CTV coverage and percent dose administered through IS needles were recorded and analyzed with descriptive statistics.

Results

Patient and tumor characteristics

Eleven consecutive patients were included in the study. Table 1 shows the T-stage, tumor size, and vessel quantity for each patient. There were no instances of procedure-related vaginal or intraperitoneal hemorrhage.

Implant characteristics and dosimetry

Ten patients underwent insertion of a tandem and ring applicator with two IS catheters within the cervix lateral to the tandem, and one of these patients also had two parametrial needles placed to cover lateral disease extension. One patient with more advanced disease was treated using

Table 1
Tumor characteristics and in-field vessel quantity for each patient

Patient	FIGO T-stage	Tumor size (cm)	Number of vessels (superior cervix)	Number of vessels (inferior cervix)
Patient 1	IB2	9	5	3
Patient 2	IIA2	5	3	2
Patient 3	IB2	9	5	4
Patient 4	IB2	5	1	2
Patient 5	IVA	8.5	4	3
Patient 6	IIA2	5	7	4
Patient 7	IB2	4	3	3
Patient 8	IB2	4	6	11
Patient 9	IB1	3.5	2	3
Patient 10	IIB	4	2	4
Patient 11	IB1	3	4	7

FIGO = International Federation of Gynecology and Obstetrics.

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