Multichannel vaginal cylinder commissioning and dosimetric assessment

K Dou, [1*] PhD, M Jacobs, [2*] MD, B Li, [1] F Lerma, [1] PhD, and A Halthore, [2] MD

[1]MedStar Health RadAmerica Mercy Medical Center Radiation Oncology, Baltimore, MD

[2]Mercy Medical Center Radiation Oncology, Baltimore, MD

JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING EASTERN TIME [GMT-4]

ABSTRACT

Elekta multichannel vaginal cylinder (MCVC) applicators in use for the high dose rate brachytherapy with the Elekta Flexitron were commissioned and dosimetrically assessed. Clinical application with the MCVC applicators has been successfully fulfilled in our department. Looking into tumors as a function of depth from 5 to 10 mm, the multiple peripheral channels are able to modulate radiation dose in order to conform to the targets while effectively sparing organs at risk (OAR). The MCVC applicators have shown significant advantages over the single channel vaginal cylinder (SCVC) in terms of the target dose conformity and OAR sparing for the deeper seated targets.

PURPOSE

Multichannel Vaginal cylinder (MCVC) brachytherapy has potential to well sculpture radiation dose to the target because of the MCVC physical structure of a central channel together with multiple peripheral channels. This MCVC design allows more flexibility for dose optimization to the target over the single channel vaginal cylinder (SCVC) while sparing dose to nearby organs at risk. The current work presents MCVC commissioning, dosimetric evaluation and clinic application.

METHOD

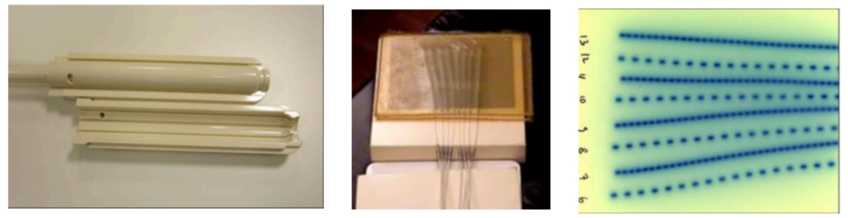
Integrity and design specifications of each cylinder , i.e., 25, 30, and 35mm in diameter were assessed with physical measurements and CT scans. The dwell source position of the cuffed catheters was verified with a source position simulator and Gafchromic film EBT3. Dose verification was performed with a Gafchromic film EBT3 and hand calculation. The Gafchromic film EBT3 was calibrated with the 6MV photons from a Varian TrueBeam.

An Elekta Oncentra version 4.5.3 was served as a planning system. An inverse planning (IPSA) was used for the dose optimization. A study for the lesions as function of depth from 5mm to 10mm was carried out for dosimetric evaluation using a 3cm multichannel cylinder. MCVC versus SCVC dosimetry was compared in terms of the OAR's dose at 2cc (D2cc) and at 1% of the OAR's volume.

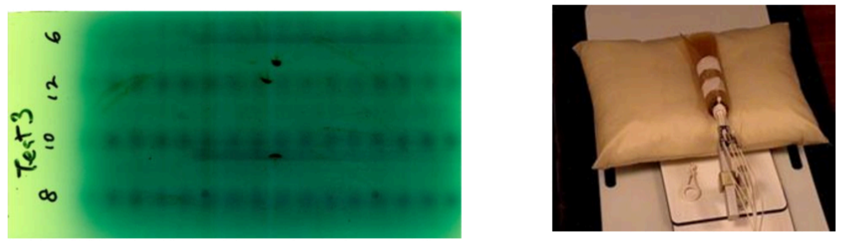
RESULTS

1. Physical dimensions for the applicators were found to meet manufacturer specifications. Integrity checks revealed no cracks or damage to any part of the applicators.
2. Verification of the dwell source position of the cuffed catheters was carried out as shown in Fig. A and B using the Gafchromic film EBT3. A source position simulator was used to verify the index compared with an exposed film. The index 1287mm was obtained from both measurements above. Fig. A used a solid water phantom where the catheters were covered with a bolus while the MCVC applicator was wrapped with a bolus in Fig. B. The central channel index was verified to be 1300mm
3. Radiation dose was calibrated using an EBT3 film wrapped MCVC applicator delivering 700cGy to the MCVC applicator surface and the film. The film was read by an Epson scanner. The data were analyzed using the Mobius DoseLab Pro as shown in Fig. C where the average difference of less than 4% was obtained except the outstanding value giving 7% off. All measured dose points versus calculated ones were consistent within 7 %.

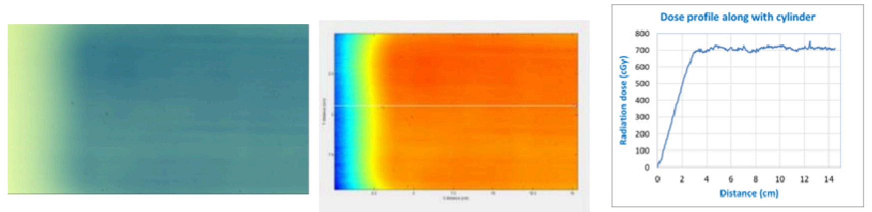
A



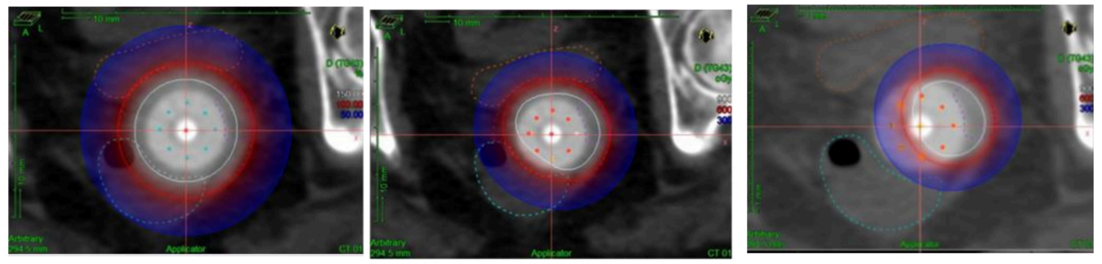
B



C

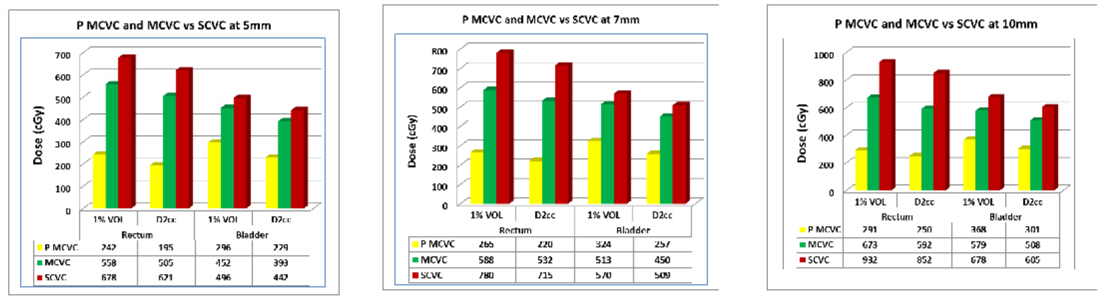


D



(a) SCVC (b) MCVC (c) P MCVC

E

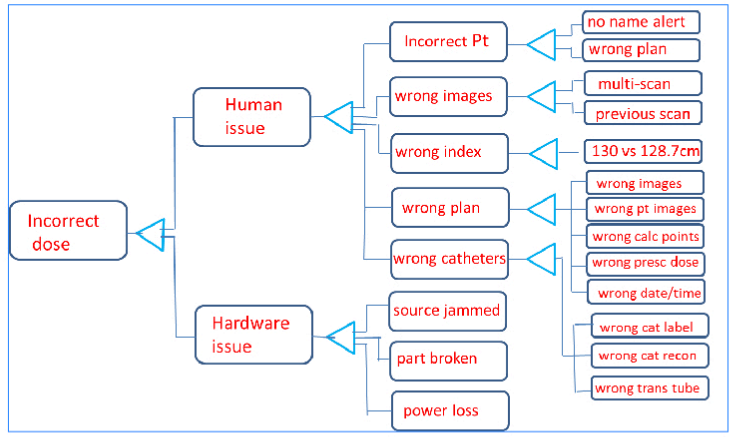


(a) at 5mm (b) at 7mm (c) at 10mm

4. Simulating the lesions in the depth ranging from 5mm to 10mm were dosimetrically evaluated among 3 different treatment plans, by activating (a) a single central channel for SCVC, (b) all MCVC channels and (c) only 4 MCVC channels (PMCVC) as shown in Fig. D. Corresponding D2cc and 1% vol of the OARs were collected and plotted in Fig. E. Both D2cc and 1% vol for MCVC versus SCVC was reduced by about 20% in rectum dose in the 5 mm depth. For the depth range of 7 to 10mm MCVC achieved a big drop in rectum dose compared to SCVC by about 35% for D2cc and 1% vol and similarly by about 15% drop in bladder dose. Activating the selected MCVC channels (PMCVC) in Fig.D(c) has shown advantages in conforming radiation dose to the target while sparing the rectum and bladder. Fig. E(c) showed a more than 50% dose drop in rectum for the PMCVC vs MCVC and also about 4 times lower in rectum dose for PMCVC compared to SCVC.

QUALITY MANAGEMENT

The American Association of Physicists in Medicine (AAPM) Task Group Report 100 (TG100) outlined a general strategy of quality management aiming at preventing the medical event from happening prior to clinical treatment[1]. Based on the TG100 the quality management has three important components of process mapping, failure mode and effect analysis (FMEA) and fault tree. We came up with the following fault tree from MCVC process mapping and FMEA. Correctly constructing and understanding the fault tree is the start point to block the failures.



SUMMARY

MCVC was successfully commissioned for clinical application. MCVC is able to significantly sculpture radiation dose to the target based on treatment length, depth, and target volume while sparing organs at risk. The MCVC is recommended to use for treating the lesions at or beyond 5mm depth. Constructing process mapping, FMEA and fault tree for creating your own checklist would be very helpful in order to block failures.

REFERENCES

[1] M. Saiful Hug, *et al*, "The report of Task Group 100 of the AAPM: Application of risk analysis methods to radiation therapy quality management", **Med. Phys. 43** (7), 4209 – 4262, 2016.

CONTACT INFORMATION

Kai Dou, PhD, kdou@mdmercy.com

Maria Jacobs, MD, mcjacobs@mdmercy.com