Chapter 6

CONCLUSION

The combination of external beam therapy and brachytherapy is an effective method of treatment for the cancer of the uterine cervix. Brachytherapy started with low dose rate systems but has now been almost replaced by high dose rate systems. Bladder and rectum are the two organs at risk for HDR treatment. The dose to these organs can be reduced by increasing the distance between these organs from the applicator containing the source. Most of the centers in India resort to gauze packing to achieve this goal.

The present study is an attempt to arrive at a solution for a substitute for packing material to reduce rectal and bladder dose of patients with carcinoma of uterine cervix undergoing high dose rate brachytherapy. This will result in the reduction of complication rates and lead to a better quality of life.

Thorough quality assurance tests were done periodically to ensure consistency of various parameters of the machines involved and were found within tolerance limits. The variation in “vendor-quoted” and measured values of source activity were found within acceptable limits.

In the present study, the rectal and bladder dose variations between fractions were studied using data obtained from patients who were treated using gauze packing. 30 consecutive patients who were treated
using microselectron-HDR were selected. It was found that there existed a significant variation in rectal dose ($F=4.811$, $p=0.032$) while bladder dose variation between fractions was not significant ($F=0.032$, $p=0.858$). This variation in rectal dose may be attributed to the variation in a) the geometry of the applicator, b) variation in packing, c) response of tumor due to radiation, d) difference involved in the dosimetry such as the selection of rectal points, reconstruction of the applicator and dwell position selection in IU and ovoids. The selection of bladder points was less ambiguous as the Foleys balloon containing 7cc diluted contrast agent was well visualized in the films. The source selection pattern in IU was uniform and this might have influenced the non-variability of bladder dose.

The study also tried to see the variation of rectal and bladder doses, obtained when the dwell positions of the first plan for the first sitting were simulated on the second (2bldr1, 2rtm1) and vise-versa (1bldr2, 1rtm2). These rectal and bladder dose values were compared with the actual rectal and bladder doses of the second (2B, 2R) and first (1B, 1R) fractions. No significant differences were found between them. This could be attributed to the fact that all the plans under study were done under thorough simulation and any adjustment felt during simulation for the applicator position was corrected before taking the orthogonal films.

The differences in planning by different observers were studied using 35 sets of orthogonal films. Same guidelines were given to five planners and the planning details including the rectal and bladder doses, dwell positions selected in ovoids and intrauterine tubes were collected and studied. A significant difference was observed on rectal ($F=3.407$, $p=0.01$) and bladder ($F=3.284$, $p=0.013$) doses obtained by different observers. The significant difference obtained for rectum can be due to difference in the selection of the rectal points, the selection of sources in ovoids, differences in reconstruction of the ovoidal catheters etc. The bladder dose variation
might be due to the difference in selection of sources in IU and inadequate packing reducing the distance between bladder and applicator. At smaller distances, the dose variation would be large for small changes in distance when compared to the change in distance when the source and dose point distance is large. This study also strongly supports the concept of same loading pattern of sources in intrauterine tube and ovoids to get a consistency in the volume treated. It is also necessary to have a clear delineation of the posterior vaginal surface to identify the ICRU rectal points for avoiding the difference in the selection of rectal points. Uniformity in the rectal and bladder packing is another requirement.

To avoid the differences in packing between fractions, a reproducible device that serves the purpose of packing would be helpful. The outcome of the present study is the production of a device (pending patent) called latex balloon. The balloon is made of latex material, a low cost, easily available and biocompatible material used worldwide in the health sector. It was designed for Standard Gynecological applicator (M/s. Nucletron Pvt Ltd, India) with medium ovoids. The length and width of the balloon are 7.5 cm and 5.5 cm respectively. The space between the two balloons is equal to the diameter of the flange (2 cm). A differential thickness was adopted as the part in touch with the applicator did not require much expansion as that near to the organs. Hence, a thickness of 0.55 mm was used for the outer thin part and 1.7 mm for the inner thick part. The part, which is coming near rectum, is named as R-part and that near to bladder as B-part. A hole made at the joining part of the balloon could help in negotiating the IU tube. It can be used along with the applicator.

The efficacy of the device was tested physically and biologically. The physical tests of the balloon reveal its capacity to withstand the amount of fluid pushed in to retain the required separation of the critical structures. It can withstand a minimum of 800 cc without bursting at
atmospheric pressure. The balloon showed very little attenuation of the radiation beam and did not influence on the dose towards the lateral sides. Water mixed with a contrast medium is pushed into the bladder and rectal parts. This expands the balloon and increases the rectal and bladder distance from the applicator thus reducing the dose to these critical organs. Moreover, the anterior and posterior vaginal surfaces can be clearly visualized. The amount of water, as tolerated by the patient, pushed in to the B and R parts of the balloon assessed during simulation can be reproduced in successive fractions. Thus, packing can be made more or less uniform.

The planning system is incapable of considering any inhomogenieties in the path of the radiation beam. Instead, it calculates dose to any point assuming the medium as water. The balloon inflated with water can be considered more of a water medium compared to wet gauze packing though the latter is taken as water equivalent.

The applicator insertion procedure at our centre is generally done under conscious sedation. The gauze packing procedure induces more pain to the patient. The use of balloon not only reduces the applicator insertion time but reduces the pain during the procedure. The independently expandable nature of the balloon is highly beneficial to adjust the packing effect felt during simulation or planning. This not only excludes reinsertion of the applicator and repacking to obtain the expected geometry of the applicator but also saves theatre and staff time resulting in the treatment of more number of patients.

The balloons were used in 102 sittings (45 patients) and the rectal and bladder doses were calculated as per ICRU-38 guidelines. Three bladder points were taken. Five rectal points with a separation of 7.5mm on film (magnification=1.5) were considered and the average was taken for analysis.
The rectal and bladder doses obtained for the first sitting using
the balloon inflated from 20cc (standard volume) to the maximum volume
tolerated by the patient (commonly 30cc) were analyzed and showed a
significant reduction in rectal doses \( F=3.54, p<0.008 \) with an average
reduction of dose from 78.1% to 62%. Paired t-test done on the bladder
doses showed that the reduction was not significant but the average dose
was found to reduce from 81.3% to 74.8%. The same trend was observed in
second and third sittings also.

A study on the reproducibility of rectal and bladder doses
obtained using balloon was done. Patients who completed their first and
second fractions (N=35) and all the three fractions (N=21) were considered.
The rectal and bladder doses obtained from first and second sittings were
compared and no significant difference was found in both rectal \( F=0.003, \)
\( p=0.960 \) and bladder \( F=0.058, p=0.81 \) doses. The rectal \( F=0.624, \)
\( p=0.539 \) and bladder doses \( F=0.002, p=0.998 \) obtained from all the three
fractions were also compared and no significant variation was seen.

The use of balloon was found on par or more effective in
reducing the dose to critical organs compared to conventional gauze
packing. The rectal and bladder doses of 43 patients who had undergone
treatment using gauze packing were noted from their records and compared
with that of a similar number of patients with balloon. A reduction of 17.9% in
rectal dose was obtained using the balloon compared to gauze packing. A
significant reduction in bladder dose was also noticed and the use of balloon
could reduce it by 17%.

The geometrical variation of the applicator parameters and its
spatial co-ordinates with respect to the bony landmarks of the individual
patients, within fraction and between fractions were studied. The geometrical
variation of all the parameters within fraction were studied with an intention of providing added comfort to the patient.

The changes in the following geometrical parameters were studied when the balloon was inflated from the standard volume (20cc) to the maximum volume: 1) IU angle, 2) beta angle, 3) the inter-ovoid distance, 4) pelvic angle, 5) alpha angle, 6) bladder-ovoid-axis angle, 7) SP-IU distance, 8) S1-S2 to bladder distance, 9) bladder-ovoid distance, 10) bladder-rectum distance, 11) vertical displacement and 12) Os-Ovoid distance. The spatial co-ordinates (X, Y, and Z) of intrauterine tube, Right and Left ovoids and Os had little effect on expansion of the balloon to higher volumes. A significant change was observed only in the bladder-rectum distance (p<0.001), which increased on expansion, as expected. It was found reproducible on successive deflation and inflation of the balloon. This has the advantages of providing consistency and comfort to the patient. This analysis also suggests that the additional volume pushed into the balloon can be taken out after simulation and it can be pushed in immediately before the onset of treatment. This will make the patient comfortable during the waiting time between the treatment planning and execution compared to any other packing methods.

The geometrical parameters were found to change between fractions but these changes did not show any influence on the rectal (average) and bladder (maximum) doses obtained using balloon. A single observer did the treatment planning using balloon and hence the observer influence on planning and source selection is excluded. The following factors would be the reasons for the reproducibility in rectal and bladder doses between fractions:

1. The increased distance achieved in separating bladder and rectum between fractions
2. a given pattern of source selection in all sittings
3. reproducible packing effect by inflating the balloon to the same volume as used for previous fractions

Inter-observer variation in the dose to rectum and bladder was also carried out for patients treated with balloon. The same instructions, as given for planning of patients with gauze packing, were given to four planners. On analysis of the planned data for 30 patients it was found that there was no significant variation either for bladder ($F=0.9, p=0.444$) or for rectum ($F=2.483, p=0.064$). Since the vaginal surface can be clearly seen on the lateral film, the error in the selection of rectal points could be excluded. The selection of dwell positions in IU by different observers was found to vary. This however, did not have any influence on the bladder and rectal doses, probably due to the increase in distance of the bladder and rectum from the applicator.

A follow up of the patients who underwent balloon packing did not show any adverse effects or complications in a two-year period.

After deflating the balloon, it can be removed along with the applicator. With gauze packing, while removing, there is a chance of leaving behind gauze pieces inside the patient, which can lead to infection. The chance of infection with the balloon is absent as it is designed for one-time use and can be neatly and safely removed along with the applicator.

In modern brachytherapy suits (IBU), all procedures such as applicator insertion, simulation, planning etc can be done in a single room without moving the patient from the treatment table. The use of balloon can still reduce the time required for the procedure. The variation in applicator placement by different radiotherapists is reported to be significant between observers mainly because of packing. The use of balloon can exclude such problems.
Scope for future work

The use of the disposable and low cost balloon removes the uncertainty in the selection of the rectal points and can significantly reduce the rectal and bladder doses. The study using the balloon is based on planning using orthogonal films. The evaluation of the balloon with three-dimensional CT-based planning using CT compatible applicators would be desirable to support the efficacy of the balloon.

In the present study, water was used for inflating the balloon. Instead of water, radiation attenuating solutions can be tried that would considerably reduce the rectal and bladder dose. Imaging can be done using water and at the time of treatment, solutions whose mass attenuation per length is known, can be pushed into the balloons.

Even though the balloon was holding the applicator in position, complete immobilization could not be achieved, particularly when there was movement of patient. A very accurate immobilization device connected to the applicator externally can bring down its movement.

Another possibility is in the design of the balloon. The material of the balloon can be made to attenuate by mixing the latex solution with solutions having high atomic number. For example, Barium Sulphate solution can be mixed with latex. On mixing some properties of the latex may be lost but it can become radio-opaque. An appropriate solution which doesn’t alter the desirable properties of latex can be found which can attenuate radiation at the same time retaining the properties of latex. Similarly, the balloon can also be made transparent to visualize the OAs at the time of placement of the applicator.
It is possible to introduce a pouch/track for keeping TLD chips along the length on the anterior and posterior sides of B and R part of the balloon. This will help us to know the dose of upper and lower vaginal surface of the balloon which can be correlated to bladder and rectal doses.

This balloon is designed for the standard gynecological applicator provided by M/s Nucletron. With a minor modification, this can be extended to other applicators also. This balloon may not be useful for patients with short vagina, vaginal extension of disease or fibrosis in the vagina.

The study shows that the low cost, disposable, biocompatible balloon can be safely used in patients with cancer of uterine cervix to provide more comfort to the patient and efficiently reduce the dose to critical organs. A large-scale multicentric study is being planned to study its efficacy and lacunae if any. In India, where uterine cervical cancer is significantly high this device will be a boon to patients and Oncologists alike.