# ABDOMINAL WALL COMPRESSION AND PRONE POSITION EFFECTIVELY DISPLACE PELVIC SMALL BOWEL AND REDUCE IRRADIATED VOLUME

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## ABSTRACT

**Objectives:** Small bowel is a dose limiting structure for pelvic irradiation, which is commonly used in several cancers. Moving the small bowel out of the pelvic irradiated field results in decreasing complications. In this study, we evaluate the efficacy of abdominal wall compression and prone position in displacing the small bowel out of the pelvic irradiated field, reducing patient thickness, decreasing the irradiated volume and increasing dose uniformity.

**Material and Method:** Ten cervical cancer patients with at least 20 cms separation at center of pelvic field were entered into this study. Oral contrast medium was used to visualize pelvic small bowel. Volume of irradiated tissue and small bowel area within the treatment ports was measured in supine position before and after abdominal wall compression and in prone position. The study was performed twice in each patient.

**Results:** The distance between the Anterior and Posterior field at center of pelvic field was decrease by about 3.8 cms after abdominal wall compression and 1.6 cms in prone position. Average of reduced irradiated volume after compression and prone position was 13.14% and 5.51% respectively ($p<0.005$). Better dose uniformity was obtained. Additionally, 49.49% of the mean small bowel area was diminished by abdominal wall compression whereas 26.40% by prone position ($p<0.005$).

**Conclusion:** Abdominal wall compression and prone position were effectively able to displace small bowel and reduce irradiated volume within pelvic treatment field. These simple, safe, inexpensive and reproducible techniques may decrease complications from pelvic irradiation.

## INTRODUCTION

Pelvic irradiation is commonly used for several cancers such as gynecological, rectal, prostate and bladder malignancies. Survival benefit has been recently illustrated from chemoradiation in cervical and rectal cancer.[1-6] However, acute and chronic small bowel complication is a limiting factor for aggressive combined modalities. Small bowel is a mobile structure that could be relocated by a variety of techniques. Several approaches, both surgical and non-surgical options, have been employed to reduce the small bowel volume in the irradiated field[7-15]. Such

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methods, however, are not often feasible and practical. Another concern of radiation therapy planning is the dose homogeneity, which is influenced by the patient thickness. For parallel opposing fields, as the patient thickness increases the central axis maximum dose near the surface increases relative to the midpoint dose, especially when decreasing beam energy. This study was designed to evaluate the efficacy of abdominal wall compression and prone position in displacing small bowel out of the pelvic treatment area and reducing patient thickness and irradiated volume in patients who have abdominal thickness more than 20 centimeters. Reduction of patient thickness will improve dose homogeneity which may decrease complicaitons.

## MATERIAL AND METHODS

Ten cervical cancer patients treated at the Division of Radiation Oncology, Department of Radiology, Chulalongkorn Hospital were included. All patients must have at least 20 cms separation at center of pelvic field. Patient having previous abdominal surgeries were excluded. Oral contrast was used to locate the pelvic small bowel. Approximately 30 minutes before simulation, patients were informed to drink two glasses (about 300-400 ml) of oral contrast medium containing 1:1 barium sulfate. Radiograph of pelvic field was taken after contrast medium filled the pelvic small bowel. Upper and lower border of pelvic field was placed at upper sacroiliac joint and bottom of obturator foramen, respectively. Two-cm margin lateral to the bony pelvis was defined. The pelvic field size was approximate 16x16 to 16x19 $cm^2$.

Square-shape foam (figure 1) was used for abdominal wall compression. The dimension of the foam was 15x17x5 $cm^3$, which was closed to the field size. The foam was placed on the abdominal wall on top of the irradiated field and taped firmly to the table. The patient was encouraged to relax the abdominal wall so that the maximum compression could be accomplished (figure 2). Another radiograph of the pelvic field was taken after compression for comparison with the pre-compression film.

The distance between the Anterior and Posterior fields of the tissue at three levels, upper border, center and lower border of the pelvic field, were recorded before and after the abdominal wall compression.

After removing the foam, the patient was placed in prone position. Radiograph of the pelvic irradiated field was taken and the tissue separations at the three levels were noted as well. Irradiated volumes of the pre and post compression and prone position were assessed by multiplying the field size with the average value of pelvic fields separation.

The study was conducted twice in each patient. Compression of the abdominal wall corresponding to the first time was attempted. Body contour of a patient's lower abdomen in sagittal and transverse planes was made for illustration of isodose distribution.

Small bowel areas in the pelvic irradiated field were evaluated by delineation contrast-filling small bowel in the simulation films in each position. Small bowel areas were determined by dividing the area of opacification into 1-cm segments and summing the results of each segment. Correction of magnification factor of each film was attained. Difference of small bowel area and pelvic irradiated volume were compared and calculated using pair t-test. Comparison of the two studies in each patient was also made to study the reproducibility of the processes. We also studied transverse isodose distribution in each position to assess the homogeneity.

## RESULTS

The characteristics of treated patients are listed in table 1. The average of the reduced small bowel area was 49.49% ($p<0.0005$) and 26.4% ($p<0.0005$) after abdominal wall compression and prone position respectively. Additionally, the reduction was reproducible as shown in table 2. An example of films is demonstrated in figure 3.

The distance between the Anterior and Posterior fields at the center of pelvic field ranged from 20 to 24 cm. The mean reduction were 3.8 cm and 1.6 cm after compression with foam and prone position, respectively. Therefore, The distance between the Anterior and Posterior fields at the upper border, center and lower border in each patient was more uniform. The irradiated volume was reduced 13.14% after compression ($p<0.0005$) and 5.51% in prone position ($p<0.005$) as compare to supine position as shown in table 3.

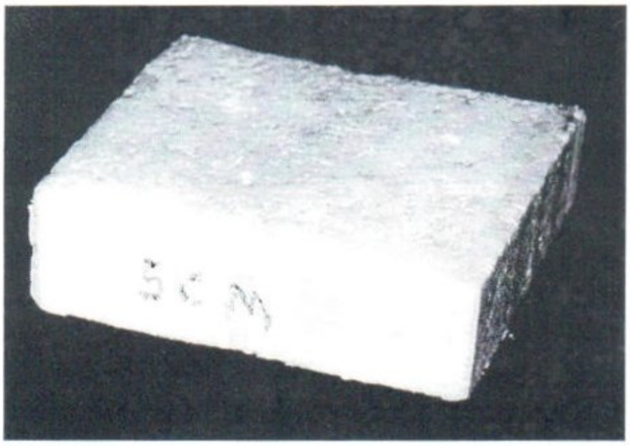


**Fig. 1**. The $15x17x5$ $cm^3$ foam used for abdominal wall compression

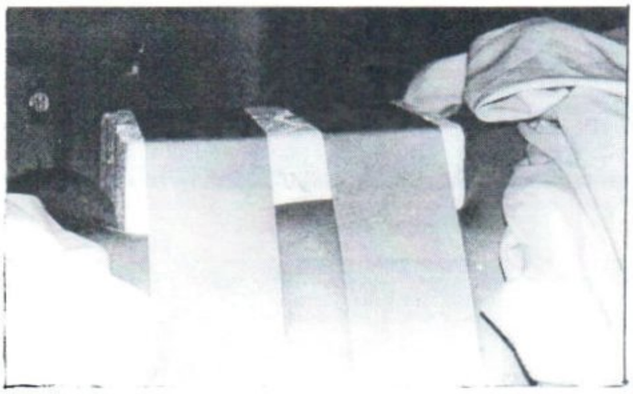
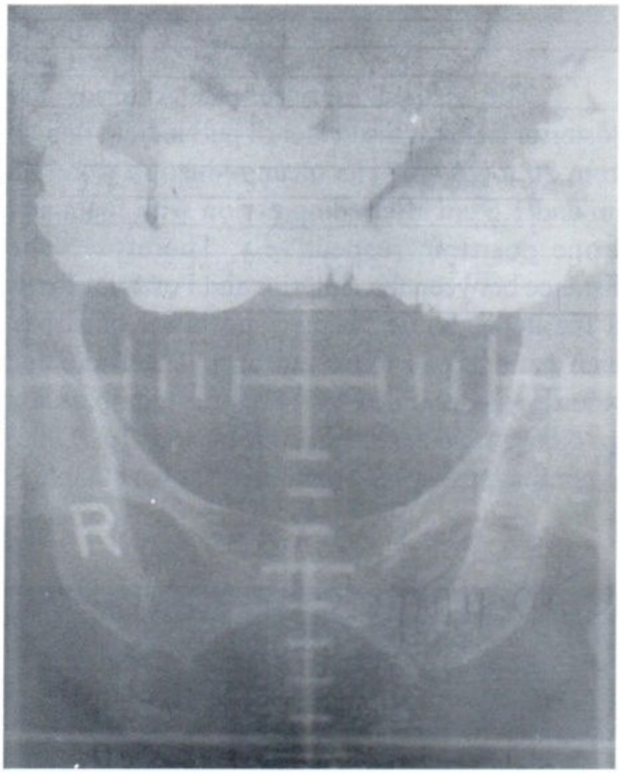


**Fig. 2**. The foam was placed on top of the pelvic irradiated field and taped firmly to the treatment table.

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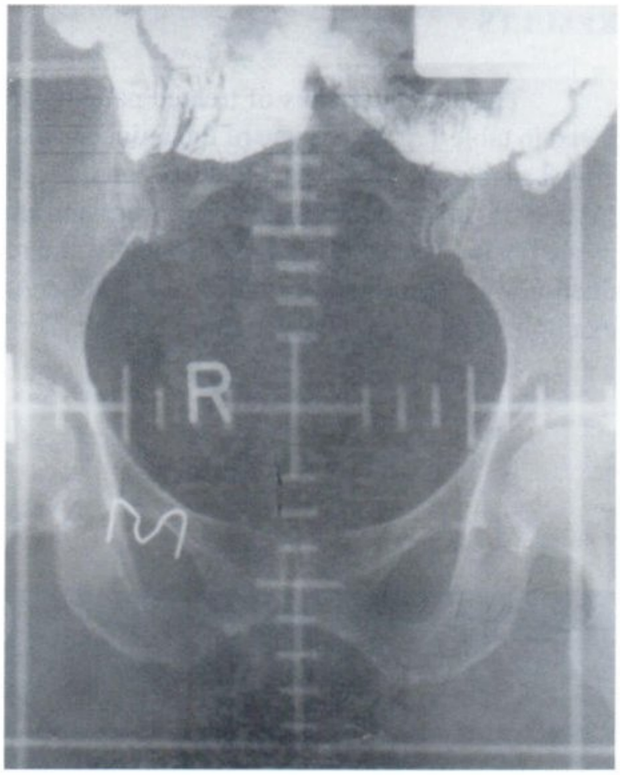


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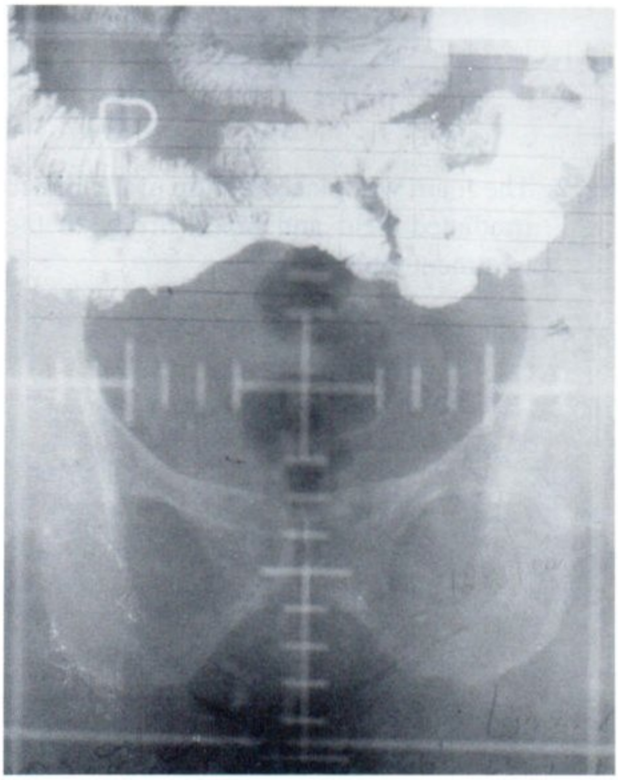


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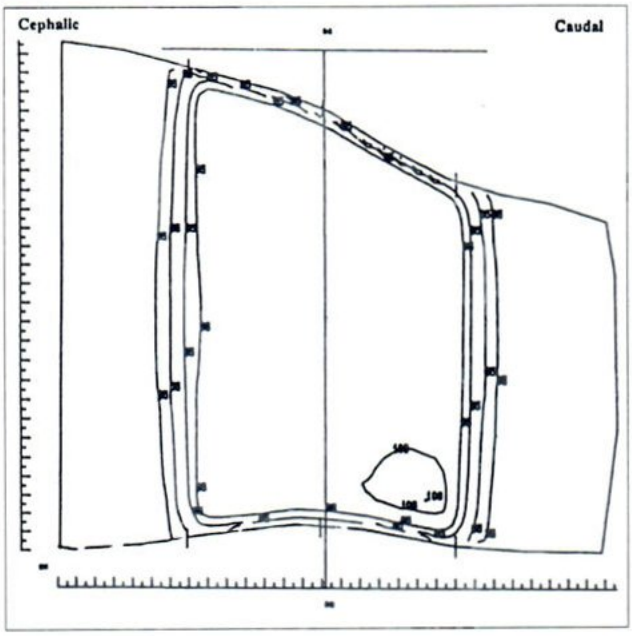
**Fig. 3**. Simulation films illustrate the contrast-filling small bowel in the pelvic irradiated field. A. Supine position before abdominal wall compression. B. Supine position after compression. C. Prone position.

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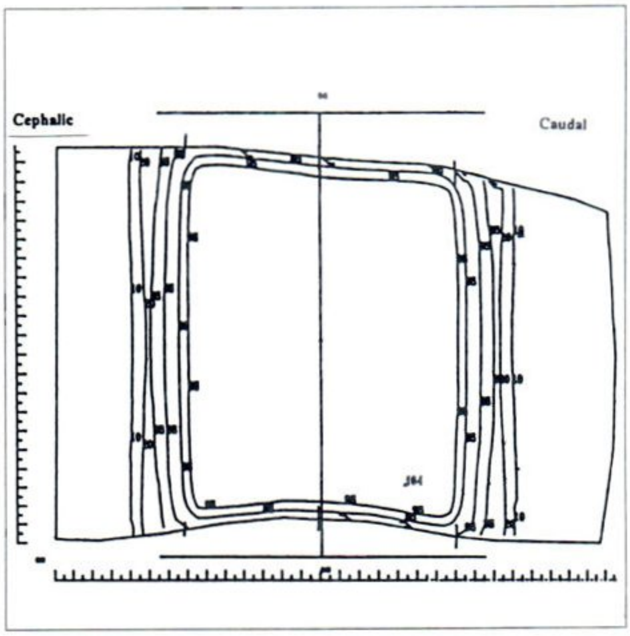


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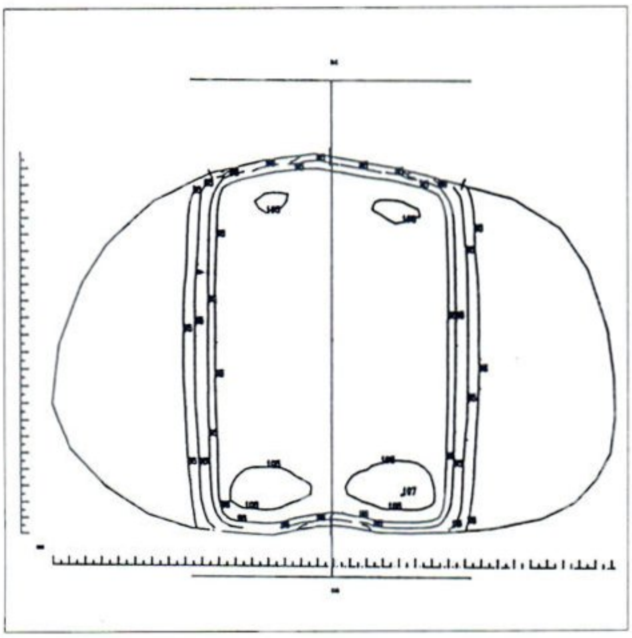

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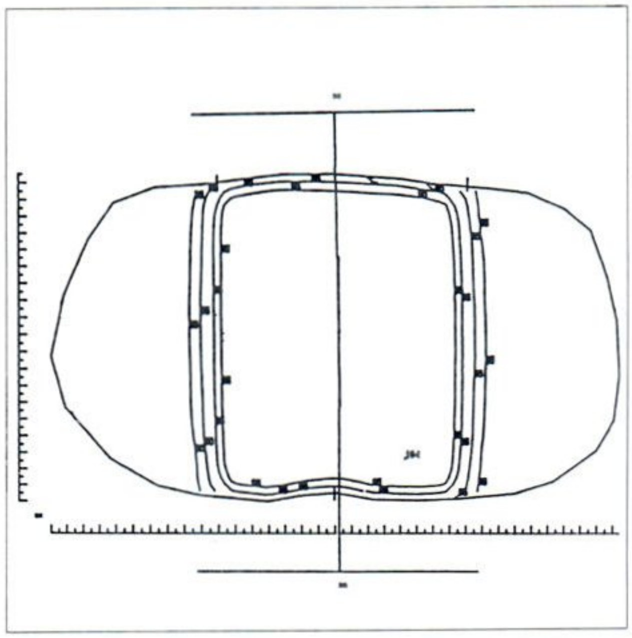
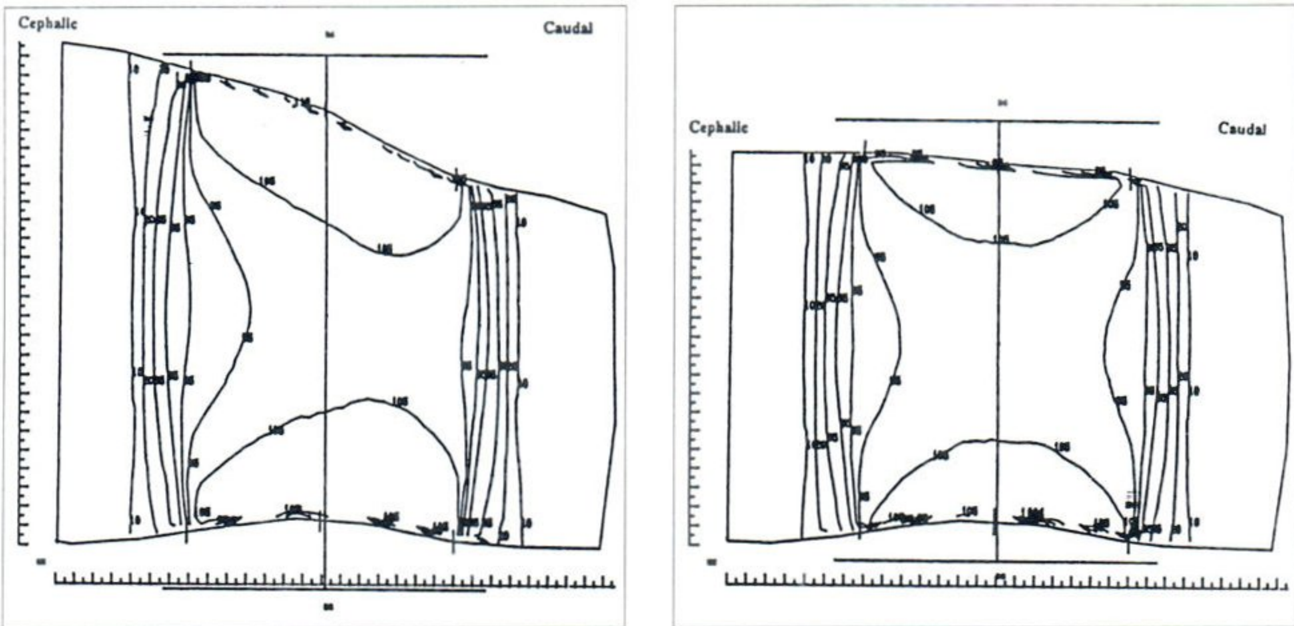


4D

**Fig. 4.** The isodose distribution in the pelvic irradiated field using 10 MV photon. Field size 17x16 $cm^2$, SAD at 100 cms.

A. Sagittal view before abdominal wall compression. (Thickness at the center 22 cms.), B. Sagittal view after abdominal wall compression. (Thickness at the center 18.5 cms.), C. Axial view at the center of pelvic field before compression, D. Axial view at the center of pelvic field after compression.




5A 5B

**Fig. 5**. The isodose distribution in the pelvic irradiated field using Co-60 machine. Field size 17x16 cm$^2$, SAD at 80 cms.

A. Sagittal view before abdominal wall compression (Thickness at the center 22 cms.), B. Sagittal view after abdominal wall compression (Thickness at the center 18.5 cms.)

**Table 1**. Characteristics of studied patients.

| No. | Age | Staging | Field size (Y x X) | Thickness of the tissue at the pelvic fields (cms)* | | |
|---|---|---|---|---|---|---|
| | | | | Precompression | Postcompression | Prone |
| 1. | 40 | IIA | 19x17 | 21.5-20-16 | 18.7-17-16 | - |
| 2. | 55 | IIIB | 19x16 | 25-23-18 | 21.5-19.5-18 | 22-22-19 |
| 3. | 61 | IIIB | 17x16 | 24-22-19 | 19-18-19 | 21-20-20 |
| 4. | 59 | IIIB | 17x18 | 21.5-21-17.5 | 17.5-17.5-17.5 | 20-20-18 |
| 5. | 70 | IIIB | 19x18 | 22-20-18 | 18-17-18 | 20-19-18 |
| 6. | 59 | IIB | 16x17 | 25-23-18 | 19.5-19-18 | 21-21-20 |
| 7. | 58 | IIB | 17x17 | 23.5-22-19 | 18.5-18-19 | 21-20-20 |
| 8. | 54 | IIIB | 17x17 | 26-24-20 | 20-19-20 | 22-22-21 |
| 9. | 30 | IIB | 16x16 | 24-22-19 | 18-18-19 | 21-21-20 |
| 10. | 60 | IIIB | 17x17 | 25-23-20 | 20-19-20 | 21-21-21 |

* Three values are thickness at the upper, center and lower border of the pelvic field, respectively.

**Table 2.** The small bowel area in the pelvic irradiated field.

| Patient No. | Investigation | A | B | A-B(%) | C | A-C(%) | C-B(%) |
|---|---|---|---|---|---|---|---|
| 1. | 1st | 111.9 | 37.2 | 74.7 (66.76) | 0* | - | - |
| | 2nd | 68.5 | 65.8 | 2.7 (3.94) | 80.4 | -11.9 (-17.37) | 14.6 (18.16) |
| 2. | 1st | 126.5 | 34.4 | 92.1 (72.81) | 98.5 | 28 (22.13) | 64.1 (65.08) |
| | 2nd | 80.2 | 22.9 | 57.3 (71.45) | 47.8 | 32.4 (40.40) | 24.9 (52.1) |
| 3. | 1st | 160.8 | 109.3 | 51.5 (32.03) | 129.4 | 31.4 (19.53) | 20.1 (15.53) |
| | 2nd | 165.3 | 67.5 | 97.8 (59.17) | 76.1 | 89.2 (53.96) | 8.6 (11.3) |
| 4. | 1st | 149.1 | 57.8 | 91.3 (61.23) | 83.2 | 65.9 (44.20) | 25.4 (30.53) |
| | 2nd | 130.5 | 62.5 | 68 (52.11) | 114.4 | 16.1 (12.34) | 51.9 (45.37) |
| 5. | 1st | 116.7 | 106.5 | 10.2 (8.74) | 115.8 | 0.9 (0.77) | 9.3 (8.03) |
| | 2nd | 152.1 | 126 | 26.1 (17.16) | 178.8 | -26.7 (-17.55) | 52.8 (29.53 |
| 6. | 1st | 146 | 108.5 | 37.5 (25.68) | 127.4 | 18.6 (12.74) | 18.9 (14.84) |
| | 2nd | 138.6 | 69.4 | 69.2 (49.93) | 116.1 | 22.5 (16.23) | 46.7 (40.22) |
| 7. | 1st | 157.2 | 42.2 | 115 (73.16) | 131.7 | 25.5 (16.22) | 89.5 (67.96) |
| | 2nd | 79.69 | 34.46 | 45.23 (56.76) | 39.23 | 10.46 (13.13) | 34.77 (88.63) |
| 8. | 1st | 52.14 | 12.85 | 36.29 (75.35) | 19.68 | 32.46 (62.26) | 6.83 (34.71) |
| | 2nd | 141.54 | 72.3 | 69.24 (48.92) | 88.56 | 52.98 (37.43) | 16.29 (18.4) |
| 9. | 1st | 141.54 | 72.3 | 69.24 (47.75) | 88.56 | 52.98 (29.65) | 16.26 (18.36) |
| | 2nd | 101.44 | 53 | 48.44 (47.83) | 71.36 | 30.08 (31.07) | 18.36 (25.73) |
| 10. | 1st | 173.92 | 77.54 | 96.38 (55.42) | 118.33 | 55.59 (31.96) | 40.79 (34.47) |
| | 2nd | 94 | 34.31 | 59.69 (63.50) | 48.17 | 45.83 (48.76) | 13.86 (28.77) |

A: The small bowel area before abdominal wall compression ($cm^2$)
B: The small bowel area after abdominal wall compression ($cm^2$)
C: The small bowel area in prone position ($cm^2$)
* The prone position was performed only once in patient number 1.

**Table 3.** Reduced irradiated volume after abdominal wall compression and prone position (%)

| Patient number | Compression | Prone |
|---|---|---|
| 1. | 10.09 | - |
| 2. | 10.61 | 4.55 |
| 3. | 13.85 | 6.15 |
| 4. | 12.5 | 3.33 |
| 5. | 11.67 | 5.0 |
| 6. | 14.39 | 6.06 |
| 7. | 13.95 | 5.43 |
| 8. | 15.71 | 7.14 |
| 9. | 15.38 | 4.62 |
| 10. | 13.24 | 7.35 |
| **Average** | **13.14** | **5.51** |

## DISCUSSION

Cervical carcinoma is the most common cancer in Thai female.[16] It is ranked to be the first in patients who were diagnosed to have cancer in Chulalongkorn hospital in 1998.[17] Radiation therapy has been considered a standard treatment in locally advanced cervical cancer. Recently, survival was shown to be improved from concurrent chemoradiation. Moreover pelvic radiation is also utilized in rectal, prostate, bladder and endometrial cancer to improve local tumor control. However, one of the normal tissues which is the dose limiting structure is small bowel (TD 5/5=4500cGy). Increased stool frequency is commonly seen during pelvic irradiation. Chronic complications include small bowel obstruction, malabsorption and perforation. There are several factors predisposing to late small bowel complications, including total radiation dose, dose per fraction, irradiated small bowel volume, previous surgery and combined chemoradiation. The severity of acute small bowel complications was associated with irradiated small bowel volume whereas late complication was related to small bowel volume receiving more than 45 Gy.[9]

Several surgical and non-surgical techniques have been employed to reduce pelvic small bowel volume.[7-15] Surgical options include omental sling, absorbable synthetic mesh sling, temporary intrapelvic tissue expander, intrapelvic prosthesis and reperitonizing pelvic floor. Such methods, however, are not often feasible. Variety of positions has been studied and shown to have a benefit of small bowel displacement from pelvic treatment field. These include prone, trenderlenburg, bladder distension, abdominal wall compression and belly board devices.

Due to their safety, simplicity, practicability and applicability to Thai patients, we chose to evaluate the abdominal wall compression and prone position techniques. The foam used for abdominal wall compression has little effect on quality of radiation. The reductions of the small bowel area in the pelvic irradiated field (49.49% and 26.4% after abdominal wall compression and prone position respectively, $p<0.0005$) should be resulted in decreasing the complications.

Furthermore, we found that reducing thickness of pelvic tissue at the upper border and center of the field made isodose distribution in the pelvic irradiated volume more homogeneous. The dose and the area of the hot spot was lower after abdominal wall compression and prone position as shown in the figure 4. Using Co-60 beam, instead of higher Megavoltage photon beam, would make this benefit more significant especially in patients who have thickness more than 20 cms at the center of pelvic field. (figure 5). After abdominal wall compression, the irradiated volume was reduced 13.14% compared to 5.51% from prone position. Cautiously, the reducing irradiated volume might not mean that the tissue was displaced from the pelvic irradiated field but in fact part of it was compressed. However, decreasing the hot spot dose and the area of hot spot combined with the increasing dose homogeneity would reduce normal tissue complications. Clinical significance of these procedures in reducing acute and late small bowel complications remains to be verified.

Assessing these two techniques, we discovered that abdominal wall compression was more effective than prone position in terms of reducing small bowel area and irradiated volume. One disadvantage of prone position is the difficulty in setting up body alignment which can make the treatment area shifted. We also studied the efficacy of the procedures twice in each patient. Using pair t-test, we found that there is no significant difference between first and second investigation confirming the reproducibility.

In conclusion, either abdominal wall compression or prone position is effective in reducing small bowel area in pelvic irradiated field. The simple, safe, inexpensive and reproducible techniques may decrease complications from pelvic radiation.

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# JUNCTION PLANE DOSIMETRY IN DIFFERENT TECHNIQUES OF COBALT-60 HEAD AND NECK IRRADIATION

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## ABSTRACT

Study of dose at the junction between lateral and anterior field in irradiation technique of head and neck cancer with a Cobalt-60 teletherapy machine was performed in anthropomorphic rando phantom with TLD-100 chips as dosemeters. Doses were compared in three different techniques ; straight field (Technique 1), couch turntable in lateral field (Technique 2) and couch turntable in lateral field with a half beam block device in anterior field ( Technique 3). When normalize dose at any point of the junction as a percentage of the dose at the center of lateral field, the mean doses in Technique 1 , Technique 2 and Technique 3 are 112.56±13.51%, 103.69 ± 12.29% and 97.20 ± 12.25% respectively. Measurements were done three times in each technique to assess for the setup reproducibility. It was found that only the reproducibility in Technique 1 and 2 was acceptable. This report is an attempt to investigate the dosimetry at the junction plane in different techniques of head and neck irradiation and suggest an appropriate technique which provides a reproducibly uniform dose distribution across the junction of head and neck irradiation with the Cobalt-60 teletherapy machine.

## INTRODUCTION

The irradiation technique of head and neck cancer commonly performed with the lateral and anterior field to treat the primary tumor and the draining lymphatics. Because of an overlapping of the beam divergence of these adjacent fields makes the dose at the junction to be non-uniform. Many studies have been reported to solve this problem. These included the use of couch and collimator rotation in lateral field,[1] the gantry rotation in anterior field (with the couch rotated $90^0$ ).[2] More recently, the introduction of asymmetric collimators in linear accelerator machine has allowed a treatment to be performed in the monoisocentric technique.[3,4] The advantage in this technique is a couch movement not being required. Therefore it is theoretically more accurate and setup reproducibility can be acquired. In our institution, the main treatment unit for head and neck irradiation is Cobalt-60 teletherapy machine due to its appropriate energy, less cost and easy maintenance. But there is a disadvantage from a large penumbra that makes the problem of the matching field overdosage being more severe. Moreover, with a symmetric collimating system, the monoisocentric technique cannot be performed by this unit. In this work, we proposed to investigate for the junction plane dosimetry in different techniques of head and neck irradiation and determine a suitable technique that may provide both a good dose uniformity at the junction and setup reproducibility to be considered as our routine treatment technique.

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## MATERIALS AND METHODS

Firstly, the lateral and anterior treatment fields were defined on a rando phantom by the Shimadzu conventional simulator with 80 cm. source–skin–distance. From simulation, junction was shown at the level of a thyroid notch. Measurments of dose at the junction were performed with the TLD-100 chips (LiF:MgTi, 3.2x3.2x0.9 mm,Harshaw Chemical, Germany). Because its appropriate thickness represented a good dose resolution at the junction. A 2 mm. thick of perspex sheet was trimmed to match with the neck contour of the rando phantom and thirty-seven holes were drilled in a regular pattern of six rows with a spacing of 1.5 cm. This 2 mm. perspex sheet was covered by the phantom and allowed the TLDs to be fitted and removed during the measurements.

Then the phantom was treated in Cobalt-60 treatment room with three different techniques. Each time a position of the phantom was carefully reproduced from the simulation. The details of each setting-up technique are described in the following.

## TECHNIQUE 1-STRAIGHT FIELD

In this technique, phantom was firstly treated with the two lateral opposing fields. Dose delivered to the reference point (at a half of separation at a level of field center) in each field was 100 cGy. Anterior field was given a dose of 200 cGy at depth 4 cm. All fields were treated with 80 cm SSD. Positions of the collimator and couch were confirmed to be at 0 angle in every measurement. Measuring of dose in this technique will illustrate the dose at the junction when an overlapping of beam divergence between the two fields existed.

## TECHNIQUE 2- COUCH TURNTABLE IN LATERAL FIELD

The couch turntable was introduced when phantom was treated in lateral field to eliminate the lower border of beam that diverged into the superior border of an anterior field. The couch was turned in the direction of the beam to create a transverse match with the anterior field. The angle of couch turntable depends on the length of treatment field and SSD. It can be calculated from the following equation.[5]

$$\text{Tan}\,\theta = \frac{\text{field length}}{\text{distance}} \qquad \ldots\ldots\ldots\ldots\ldots(1)$$

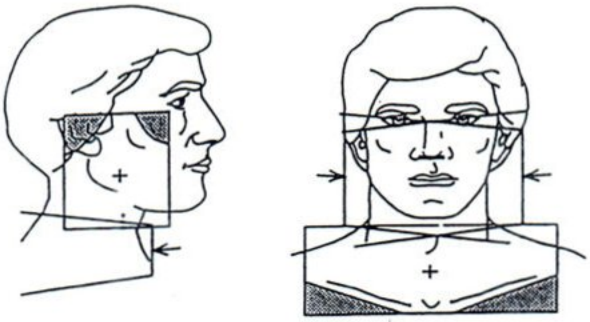
In this experiment, the angle of couch turntable is $4^0$.

## TECHNIQUE 3-COUCH TURNTABLE IN LATERAL FIELD WITH A HALF BEAM BLOCK IN ANTERIOR FIELD

A half beam block device provides a mean to reduce a penumbra on one side of the beam by shielding half of the beam at a field central axis. Therefore, when it was introduced to the anterior field, it will match with the lower border of lateral field that the couch turntable is being used. With this device, the field length of the anterior field has to be double and block the upper half of the field.

## RESULTS

The results of junction plane dosimetry in three different techniques of head and neck irradiation were presented in Fig. 3 - Fig. 5. Dose at each point was normalized as a percentage of dose at the reference point. Mean dose at the junction, dose variation (determined from a standard deviation of the mean dose) and also a setting-up reproducibility (assessed from a mean of the standard deviation from 3 measurements) are summarized in Table 1.



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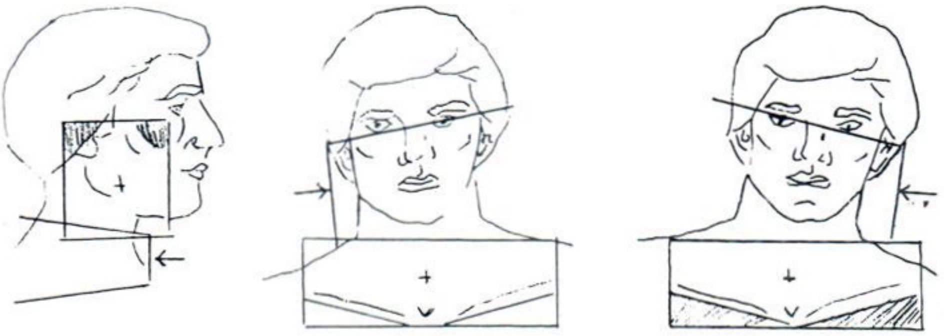

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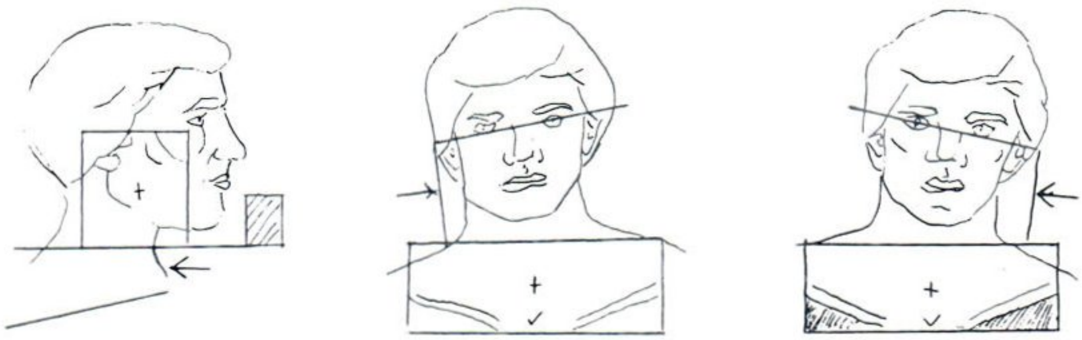

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**Fig. 1.** The diagram illustrate a) Technique 1-straight field, b) Technique 2-couch turntable in lateral field c) Technique 3 –couch turntable in lateral with a half beam block in anterior field

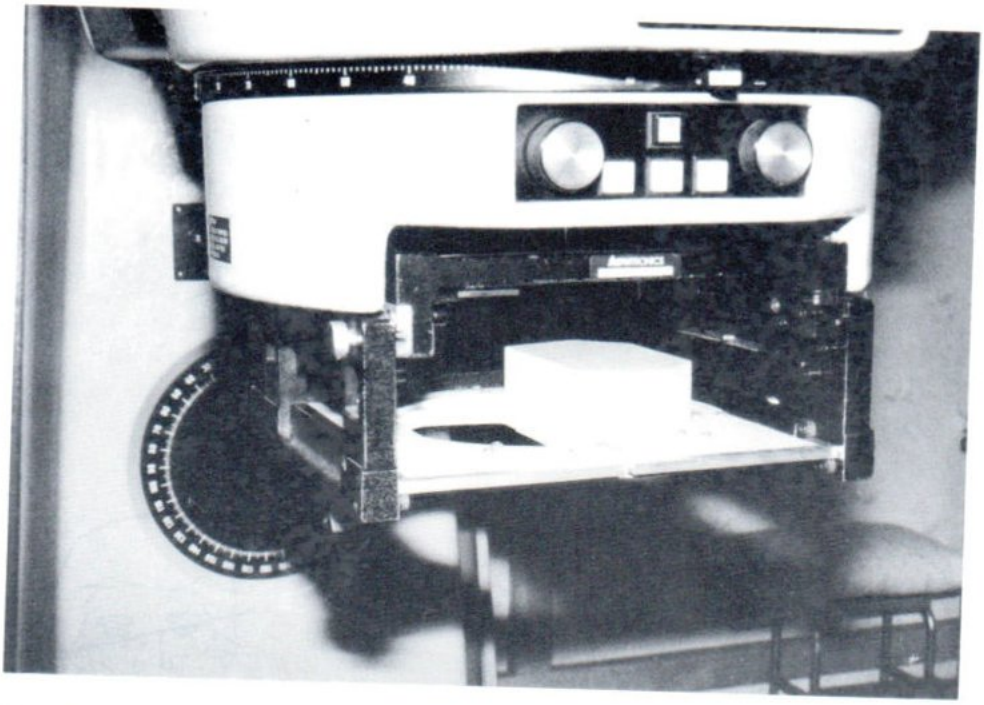

**Fig. 2.** A half beam block device

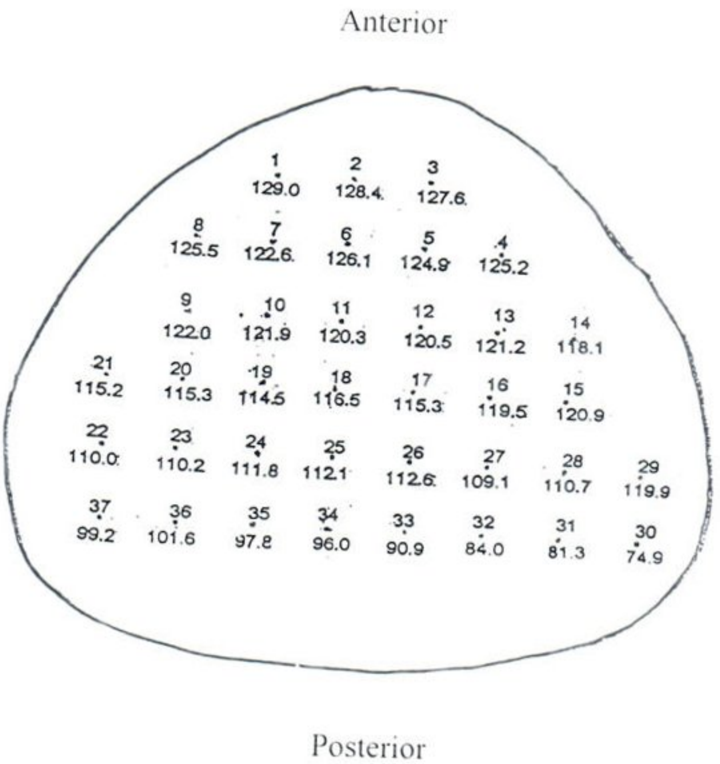


**Fig 3**. Dose distribution at a junction plane in the technique of straight field.

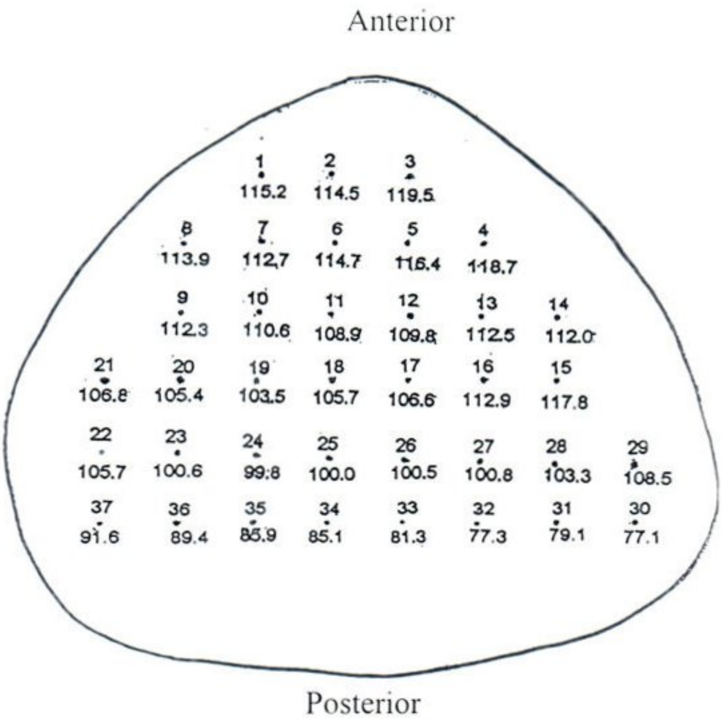


**Fig 4.** Dose distribution at a junction plane in the technique of couch turntable in lateral field.

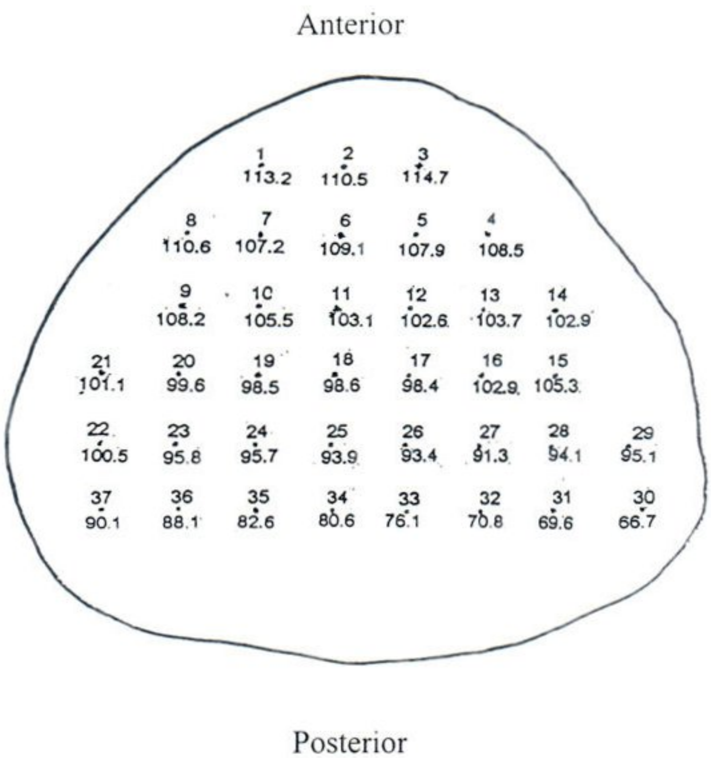


**Fig 5.** Dose distribution at a junction plane in the technique of couch turntable in lateral field with a half beam block in anterior field.

**Table 1.** Summary of junction plane dosimetry in three techniques.

| Techniques | Mean Dose | Dose variation | Reproducibility |
|---|---|---|---|
| Straight field | 112.56 | 13.51 | 2.09±1.03 |
| Couch turntable | 103.69 | 12.29 | 3.11±1.15 |
| Couch turntable+HBB | 97.20 | 12.25 | 7.72±4.55 |

HBB = half beam block

## DISCUSSION AND CONCLUSION

Numerous methods have been introduced for solving a problem of non-uniformity of the dose at a field junction.[1,2,6,-8] Recently, the technique of monoisocentric utilizing asymmetric collimation showed a potential advantage of more accurate and reproducibly dosimetry.[3,4,9] It also reduced a number of setup factors that are subjected to error by an operator. But it is a technique available with the linear accelerator unit only. In the institute that Cobalt-60 teletherapy machine still be the main treatment unit for head and neck cancer, dosimetry at the junction was required to assess for a magnitude of a field matching problem. Efforts to study a dose distribution at the junction of various techniques available with the Cobalt-6o machine was proposed. In this study we used a technique of couch turntable to solve for the divergence of lateral beam. Actually a half beam block device has a limitation in a field dimension. From simulation, the length of lateral field was 14.5 cm. That means, if a half beam block is applied, the field length required to set is at 29 cm. Since the maximum field size available for this device was 20x20 cm and when was half blocked a field was reduced to 10x20 or 20x10 cm, therefore it is not enough for the lateral field length. We found that applying a couch turntable in lateral field can minimize both area and level of high dose. Measurements in Technique 1 clearly demonstrated a level of high dose (up to 110-130%) at the junction in a large portion of anterior neck. With a couch turntable, this high dose region was decreased and presented a maximum dose not greater than 120%. Also, a mean dose in technique 1 and 2 was shown to improve from 112.56% to 103.69%. Among these techniques, the best uniformity of dose distribution was seen in technique 3. A mean dose at the junction in this technique (97.20%) was very close to a prescribed tumor dose. Moreover, the overdose was seen in a small area of neck and not greater than 115%. This high dose is still exist in the anterior neck due to the contour irregularity that we can not improve by using a compensator.

More interesting findings are dose variation and setup reproducibility. No difference in dose variation was seen in three techniques. It is unlikely in the setup reproducibility that only Technique 1 and 2 that provided an acceptable value. Reproducibility was worse in Technique 3. This may arise from a half beam block device. It required a correct position when fitted with a collimator to accurately provide the half blocked beam. Thus, it is easily subject to error by both an operator and the mechanic of the machine. In this technique, we tried to confirm the data by carefully repeating the measurements 5 times and the results were shown in Table 1.

In summary, the study of junction plane dosimetry in head and neck irradiation technique performed with Cobalt-60 suggested the technique of couch turntable in the lateral field to be appropriate. It presented both the acceptable good dose uniformity and setup reproducibility. Even though, the application of a half beam block in the anterior field had the best dose uniformity at the junction but its reproducibility was not satisfied. However, not only the junction plane but also a whole treatment volume including critical organ such as lens, thyroid and brain that dosimetry should be carefully verified prior to the application in the routine clinical uses.

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## Message from

# Professor Dr. Kawee Tungsubutra

**Editor-in-Chief, The Asean Journal of Radiology**

Dear Friends ,

Happy New Year to you all. I hope this journal had passed the critical period. We can stand on our feet and hope that our younger generation will start to run!

**Kawee Tungsubutra**
**January - April 2001.**