National survey of kilovoltage radiotherapy equipment in Denmark

RS Thing[1*], TM Haskå[2], MS Nielsen[3], HL Riis[4], H Spejlborg[5], and TH Sørensen[6]

[1] Department of Medical Physics, Vejle Hospital, Denmark
[2] Department of Oncology, Section for Radiotherapy, Rigshospitalet, Denmark
[3] Department of Medical Physics, Aalborg University Hospital, Denmark
[4] Laboratory of Radiation Physics, Odense University Hospital, Denmark
[5] Department of Medical Physics, Aarhus University Hospital, Denmark
[6] Department of Oncology, Divistion of Radiophysics, Herlev Hospital, Denmark

*Corresponding author: rune.slot.thing@rsyd.dk

Vejle Hospital
– a part of Lillebaelt Hospital

Purpose, Methods & Materials

A survey was conducted to gather information and compare the kV radiotherapy units in Danish radiotherapy departments, i.e. which dosimetry protocols each centre followed, the dosimeters used for calibration, kVp of the clinically used energies, measured half-value layer (HVL), dose rate, output factors, and depth dose measurements.

Conclusion

A national comparison of kV radiotherapy units was conducted, and overall the units were found very similar. No systematic differences were observed based on the calibration protocol. Output factor variations were most pronounced for small applicators, and such variations in output factors and depth dose could possibly be reduced if a national consensus is established.

Results

Six of the seven Danish radiotherapy departments offer kV radiotherapy, and all six centres contributed data to the study. All kV units are from the same manufacturer, and all centres use a maximum accelerating potential of 100 kVp. Beam quality as measured by the HVL ranges from 0.9 to 4.2 mm aluminium, and all centres offer at least two different clinical beam qualities (Table 1). Dose rate output varies between 3.8 and 7.5 Gy/minute for a 4 cm diameter field, depending on the beam quality and kVp.

Different protocols for the determination of absorbed dose are used, with three centres following the IPEMB protocol, two centres following the IAEA TRS 277 protocol, and one centre following the AAPM protocol. Four centres use Farmer type cylindrical ion chambers for absolute dosimetry, while two centres use plane-parallel chambers (Table 1).

Comparing the data across the centres revealed no systematic differences based on the absorbed dose protocol each centre followed. One centre had less variation in output factors as a function of field size compared to the other five centres (Figure 1), which is most likely explained by a local variation in measurement setup. There may be a slight difference in the determination of relative output of the different applicators depending on the ion chamber used for output factor measurements, but with limited data available this remains inconclusive (Figure 1). The 85% range of x-rays varies up to 2 mm for similar beam qualities, and more similar ranges are expected if all centres used the same applicator and measurement technique to determine the range (Figure 2).

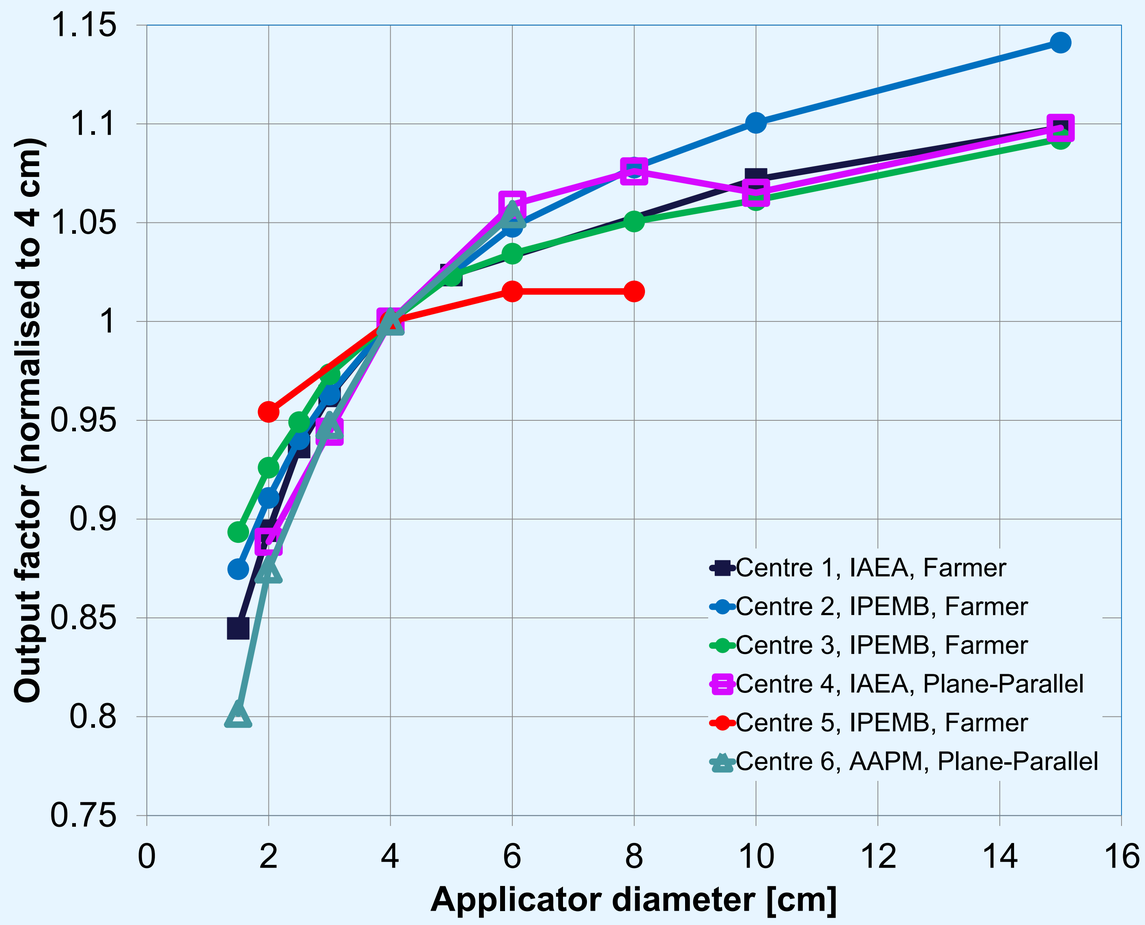

Figure 1: Comparison of output factors for similar beam qualities. One beam quality with HVL between 2.1 and 2.63 mm Al is shown from each centre, with the output factors normalised to a 4 cm diameter field. Output factors for Centre 5 has a less steep slope compared to the other centres, most likely explained by local variations in measurement setup. The present, limited, data indicates that output factor determination using a plane-parallel ion chamber may increase the steepness of the slope particularly for small applicators compared to measurements using a Farmer-type chamber.

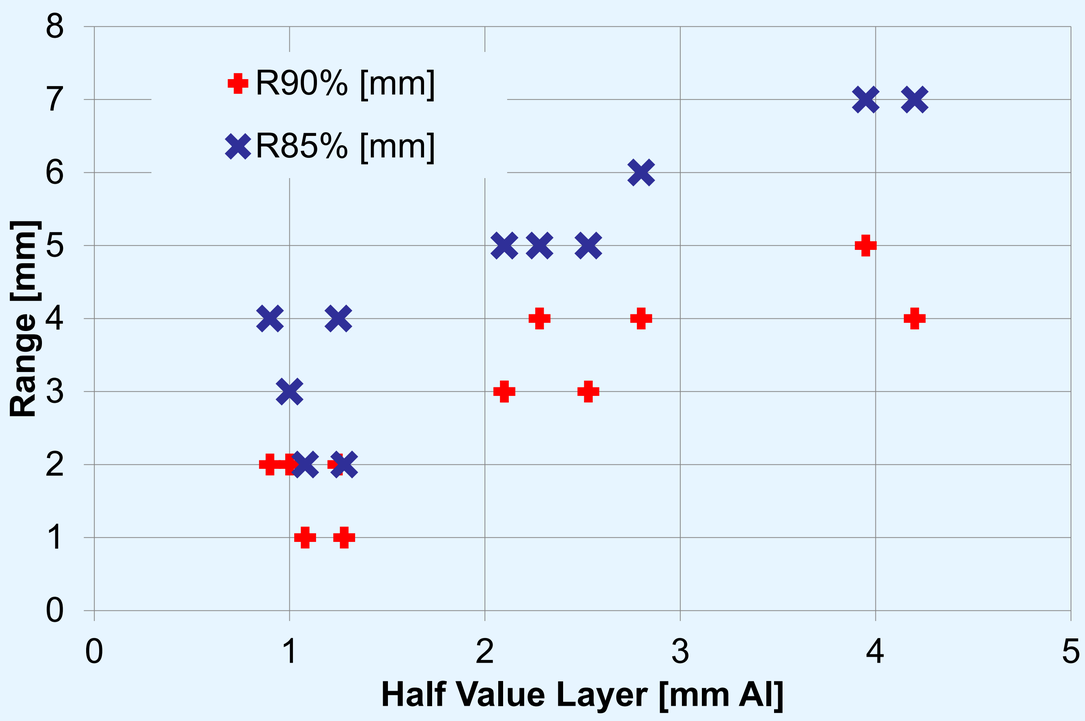

Figure 2: 85 and 90 percent range (rounded to nearest mm) of the x-rays as a function of beam quality. Range data was provided by five of the six centres. Applicator size ranges from 3 to 6 cm diameter, and accounts for some of the variation.

Table 1: Calibration protocol, reference chamber type and available beam qualities as specified by the half-value layer in aluminium for each of the six centres offering kilovoltage radiotherapy in Denmark.

Centre	Protocol	Reference chamber type	Available HVL [mm Al]
1	IAEA + BJR	Farmer	0.8 , 2.1 , 2.8
2	IPEMB	Farmer	1.08 , 2.18 , 3.9
3	IPEMB	Farmer	1.25 , 2.28 , 3.95
4	IAEA	Plane-Parallel	1.28 , 2.53
5	IPEMB	Farmer	1.0 , 2.1 , 4.2
6	AAPM	Plane-Parallel	0.89 , 2.03 , 2.63 , 4.02

References

AAPM: Ma *et al*.: AAPM protocol for 40-300 kV x-ray dosimetry in radiotherapy and radiobiology. Med Phys 2001.
BJR: Central axis depth dose data for use in radiotherapy, Br. J. Radiol., Suppl. 25, 1996
IAEA: Absorbed dose determination in photon and electron beams: An international code of practice. IAEA TRS-277, Vienna, 1987.
IPEMB: Klevenhagen *et al*: The IPEMB code of practice for the determination of absorbed dose for x-rays below 300 kV generating potential. Phys Med Biol 1996.