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Original Article

Financial implication of conformal prostate treatment

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Abstract

Objective: The objective of this study was to directly compare the cost of conformal radiotherapy used with the RTo1 trial with that of non-conformal radiotherapy of the prostate.

Method: Two methods were employed to establish the cost, a simplistic top-down method and the more complicated bottom-up method that involved breaking down the cost elements of the respective treatments and undertaking a non-participative timing study on 37 patients undergoing radiotherapy. Costs were then ascribed based on the time the staff and equipment were utilised.

Results: The total cost of radiotherapy using the top-down method for both non-conformal radiotherapy and 32 fraction conformal radiotherapy was £2890.88, compared with £3342.58 for conformal radiotherapy using 37 fractions. The costs of the bottom-up method were £2485.67 for non-conformal radiotherapy, £2717.67 for 32 fraction conformal radiotherapy and £3110.52 for conformal radiotherapy using a 37 fraction regime.

Conclusions: Conformal radiotherapy of the prostate costs significantly more than non-conformal radiotherapy which reflects the increase in complexity of the technique. Cost differences arose due to increased time in the planning stage and in the actual treatment because of an increase in equipment and staffing costs during treatment.

Keywords

Cost; radiotherapy; prostate; conformal; non-conformal

INTRODUCTION

Within medical related fields there is growing pressure to improve both the service and results with limited resources. The modification of existing treatments and new treatments need to be assessed, not only in terms of clinical outcome but also in terms of economic evaluation.[1,2] An appreciation of the costs involved within radiotherapy is particularly important, as it is perceived to be an expensive form of treatment;[3] this is primarily due to the high initial cost associated with the purchase of equipment.

One trial currently being carried out is the RT01 trial, a phase III randomised study of conformal standard radiotherapy versus conformal high dose radiotherapy in addition to neoadjuvant androgen deprivation in patients with localised prostatic cancer. This costing study aims to compare the treatment cost for conformal therapy used in the RT01 trial compared with conventional external beam radiotherapy.

Patients entering into the RT01 trial received a radiotherapy dose of either 64Gy over 6 weeks in 32 fractions or 74Gy over 7 weeks in 37 fractions. At present, the hospital in the study charges £95 per radiotherapy fraction across the board. This was calculated by dividing the annual costs for running the department by the number of fractions treated in a year. This method is the so-called 'top-down method' of cost calculation and, although easy to compute, it gives a very rough cost of treatment. It assumes that all patients are using all facilities equally. This is not however the

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case, the mould room is predominantly used by head and neck patients, the computer planning computer by radical patients, yet other treatments are effectively subsidising patients that require these services.

This method of costing is also too crude to use when looking at the cost of new treatments such as those involved within the RT01 trial. Costs can only be derived from the number of fractions used, therefore a cost difference between the low dose and high dose arm of the trial would be apparent using this method (£3040 and £3515 respectively). However, between the conventional and low dose arm of the trial no difference in cost would show as they both have the same fractionation schedule. This is despite the fact that the equipment utilised is different for the two treatment types.

This article aims to look at the costs involved within conformal and non-conformal patients by carrying out two costing studies. The first will be the top-down method of costing where the costs of the department are identified and summed, the total cost being divided by the total number of fractions per year. The second costing will be a bottom-up costing where an attempt will be made to identify the time the equipment and staff are utilised in a procedure, namely an activity based costing (ABC).

TOP-DOWN METHOD

Staff costs

Staff costs were based on the grades of staff present within the department. In keeping with previous studies[4,5] staff costs were calculated by taking the average between the highest and lowest cost (so allowing for staff fluctuation) on the pay scale and then adding London weighting and relevant teaching allowance. The figure was then increased by 15% to account for employer's contribution. For Doctors, Administrative and Clerical staff the figure was reduced by 30% in keeping with Goddard et al.[6] to account for work related to non-radiotherapy issues. Details of staff costs can be seen in Table 1.

Equipment costs

According to published data,[7] all treatment machines are expected to have a working life of 15 years and the planning computer 10 years. The annual cost of equipment was calculated from the cost of the equipment when new discounted at a rate of 5%[8] over the projected life of the equipment. This was done using the formula first suggested by Atherton[9] below. Machines and fixtures costing less than £1000 were excluded from the calculation.

Table 1. Staff costs

Staff	Annual cost
Radiographers	£ 438,513
Doctors	£ 176,055
Physicists and Engineers	£ 272,717
Administrative and Clerical	£ 70,950
Nurses	£ 21,623
Portering and Ancillary	£ 22,962
Total yearly cost	£ 1,002,820

Annual cost formulae:

$$T = n\left[\frac{Ar(1+r)^n}{(1+r)^n - 1}\right]$$

where n = number of years, A = the amount borrowed and r = the interest rate as a decimal

The department does not have any service contracts for the treatment units, servicing being carried out by the in-house engineering staff. This resource has already been included within the staff costs, however it must be noted that this cost does not include the cost of parts, which was quoted by the engineering department as being approximately £602,000 per annum. Details of all the equipment costs are found in Table 2.

Estate costs

The Projects department quoted the estimated cost of the radiotherapy premises as being £4,978,800. This was based on a floor area of 2766m^2 at a cost of

Table 2. Equipment costs

	Purchase cost	Total repayment	Annual cost	Cost per minute
SL 18	£1,000,000	£ 1,445,133	£ 96,342	£ 0.88
SL 75	£ 400,000	£ 578,053	£ 38,356	£ 0.35
Simulator	£ 390,000	£ 563,602	£ 37,356	£ 0.34
Planning computer	£ 350,000	£ 453,268	£ 45,326	£ 0.42
Processor	£ 7,500	£ 10,838	£ 722	-
Total cost to department			£218,319	-

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£1800 per m². The figure for the building amortised over a 60-year period in keeping with Goddard et al.[6] gave an annual cost of £82,980. Running expenditures were costed at £124,470 by the Projects Department. This expenditure, including running costs such as heating, lighting, gas, water, maintenance of buildings and cleaning, was based on a figure of £45 per m².

RESULTS

Using the simplistic top-down method of costing we find that the total cost per fraction is £90.34. This figure was obtained by taking the total department cost from Table 3 and dividing by the number of attendance's (22,661) for the year 1998/99. This figure compares with the £95 currently charged by the department.

BOTTOM-UP METHOD

In order to carry out the bottom-up costing, a non-participative timing study was carried out on 37 patients, 19 in the conformal arm and 18 in the conventional arm. The main activities of the treatment process were identified and divided into three costing areas:

1. Simulator (including verification and localisation).
2. Planning (including plan production and plan checking).
3. Treatment.

In the simulator, and on the treatment units, patients were timed from the point that they entered a room to the time that they left. Although not representative of the actual treatment time, this represented a period of time when the machine could not be utilised by any other patient and therefore directly attributable to the patient with prostate disease.

The staff costs and the costs for the equipment had already been calculated per annum and were divided by the number of working minutes per annum based on a 9am-5pm working day and a 5-day week to give the cost per minute of operation. As all prostate patients were ascribed to the trial no conventional treatments were available as a comparison. In order to overcome this it was decided to time patients having treatment for carcinoma of the rectum or carcinoma of the cervix as both these treatments are similar and there is no significant difference in treatment times.[4]

The staff involved in any given process was recorded and then averaged over all the cases for each treatment group, details can be seen in Table 4.

Simulator

Localisation for the conformal group was carried out on the Computerised Tomography scanner within the diagnostic X-ray department whilst localisation for the non-conformal group was on the simulator. The time spent localising both groups was significantly different (student's t-test, $p<0.0001$), the average time for conformal localisation being 19.7 minutes compared with 39.8 minutes for the conventional group.

The CT scanner was based within the diagnostic department and as such the capital; running and maintenance costs are born by the imaging department. This cost was therefore ignored in the top-down costing method, but cannot be ignored using activity based costing.

The verification process utilised the same piece of equipment for both groups and the staffing levels were consistent between the two groups. The time taken to perform the verification process was however different (student's t-test (t), $p=0.001$), the non-conformal verification taking 28.7 minutes compared with 47.7 minutes for conformal verification.

A second verification was carried out on all patients half way through treatment. No significant

Table 3. All costs

Cost area (per annum)	Amount	% Contribution
Staff	£ 1,002,820	49.0
Equipment	£ 218,321	10.7
Spares and Servicing	£ 618,500	30.2
Estate	£ 207,450	10.1
Total	£ 2,047,091	

Table 4. Mean radiographer staffing levels

Unit	Radiographer	Senior 2	Senior 1	Superintendent 3
Simulator	1	1	1	0
SL-18	1.67	1	0	1
SL-75	1.52	0.94	0.79	0.94

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difference existed in staffing levels or the time the equipment was utilised for. The cost for both groups is therefore identical at £4.07.

Volume placement

The process of placing a volume on the outline was performed by the doctors and took 7.2 minutes for the conventional group compared 137.9 minutes for the conformal group. These times were significantly different from each other, (t), $p<0.0001$.

Planning

The physics staff carried out both the plan production and plan-check. No significant difference in the grade performing the task was seen for either of the processes, Chi squared tests produced results of (χ^2), $p=6.4$ and $p=0.1$ respectively. The average grade associated with both tasks was a grade B physicist. The equipment usage for the two processes was different, the plan production requiring a planning computer whereas writing the plan up and the plan-check required no equipment, so giving a difference in equipment costs between the two tasks.

The time taken to carry out the two processes was also different as was the time taken between the conformal and non-conformal group.

Treatment

The mean treatment time was the same for both groups: 13.2 minutes. However, on days when on-treatment films and electronic portal imaging was used the mean treatment time rose to 21 minutes within both groups, a significant difference from treatment only times, (t), $p=0.0001$. This procedure was carried out an average of three times for each group.

The patients were treated exclusively on two separate units, each of which had a different initial investment associated with it (Table 2), and significantly different staffing levels (χ^2) $p<0.001$ (Table 4). Therefore, although the times taken to treat the two groups is the same a different cost per fraction is expected.

Fixed costs

Costs that could not be ascribed to the patient directly remained as a fixed cost (Table 5). These employment costs consisted of the superintendent radiographer, doctors, physicists (the equivalent of two grade B physicists were excluded from this section, see the planning section), administrative/clerical, nurses and ancillary staff. Porters were also excluded from this cost as none of the patients within the study required their services.

The linear accelerator used for the conventional group due to its age did have a higher cost associated with its maintenance, primarily due to the requirement of a yearly camera change for its Electronic Portal Imaging Device (EPID) system. The camera cost was a substantial part of the money set-aside for spares and servicing. It was felt however that the addition of this cost to the conformal treatment cost was a reflection of the particular unit rather than the treatment itself as the expected life span of an EPID camera should be in the order of 3–4 years. It was therefore decided to treat estate and spares and servicing costs as a fixed cost. Based on these figures and using the number of patients treated in the year 1998/99 quoted earlier a fixed cost per fraction of £57.66 is derived.

Total cost

The total cost for the respective treatments seen in Table 7 were calculated using the figures shown in Table 6 and using the formulae on the next page.

Table 5. Fixed costs

Cost area	Amount
Staff	£ 479,869
Equipment (Processor)	£ 722
Spares and Servicing	£ 618,500
Estate	£ 207,450
Total	£ 1,306,541

Table 6. Costs per recording area

	Conformal		Non-conformal	
	Staff	Unit	Staff	Unit
Localisation	£ 13.57	-	£ 27.37	£ 13.60
Verification	£ 32.83	£ 16.32	£ 19.75	£ 9.82
Second verification	£ 8.19	£ 4.07	£ 8.19	£ 4.07
Volume	£ 11.39	-	£ 2.59	-
Planning (Computer)	£ 20.68	£ 37.05	£ 15.37	£ 27.73
Planning (Other)	£ 11.27	-	£ 11.27	-
Total Planning costs	*£ 155.37*		*£ 139.76*	
Treatment (no films)	£ 10.88	£ 10.45	£ 10.03	£ 4.16
Treatment (with films)	£ 19.30	£ 18.38	£ 17.63	£ 7.32

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Total cost formula:
Total cost=(Total Planning cost) + (fixed cost ×#)+(treatment cost (no films)×(#–3)+(treatment cost (films)×3)
Where # = the number of fractions

It can be seen from Table 7 that using the bottom-up costing method that a conformal treatment using the same number of fractions (32) gives an increase in cost of 8.5% over non-conformal treatment. This figure increases to 20.1% when the number of fractions increases to 37.

DISCUSSION

Cost differences between the conformal and non-conformal groups were apparent in virtually all areas of both planning and treatment. The cost to the conformal group was higher due to two fundamental reasons. Firstly the treatment is more complicated to plan and therefore requires greater time and effort on behalf of the staff involved to produce the final product. Secondly the equipment utilised for the treatment is more sophisticated and therefore more costly. Associated with this second issue is the fact that as the equipment is more sophisticated the staff ratios on the equipment are more heavily weighted towards the senior grades (Table 4). This again has an impact on the cost of treatment.

The figures produced using the bottom-up (ABC) costing method were lower than either that used by the department or the cost calculated using the top-down method. This is due to a number of reasons, firstly the costing methodology reflects the use of staff and equipment within the department. The radiotherapy treatment technique for carcinoma of the prostate is relatively straight forward compared to some and is therefore relatively quick to perform. Also the treatment does not require the use of the mould room or its staff, the patients are generally mobile and so do not require the use of porters (all patients within the study were mobile and no recorded use of porters time was noted). Therefore using the ABC costing method all these costs can be excluded from the calculation for prostate patients.

Table 7. Total cost implication to the radiotherapy department

	Bottom-up costing (ABC)	Top-Down costing
Non Conformal	£ 2,485.67	£ 2,890.88
Conformal (32#)	£ 2,717.67	£ 2,890.88
Conformal (37#)	£ 3,110.52	£ 3,342.58
% Difference 32#	8.5	0
% Difference 37#	20.1	13.5

However, it is also possible to criticise a number of assumptions taken in the methodology, the main one being that it was assumed that the machines and staff would be utilised fully during a 9–5 working day, 5 days a week, 52 weeks a year. This is not the case; public holidays cut down the available number of working days of a unit as does the requirement to have the machines serviced on a regular basis. Also there is the unpredictability of referral patterns, which means that although the units and staff will have busy periods there will also be periods of time when they are not being fully utilised during the day. Associated with this latter point is the need of the department to do overtime in busy periods at an increased rate of pay for the various members of staff needed to cover such work. In general however it is possible to say that the figures quoted using the bottom-up method are an under approximation of cost.

An increased cost of 8.5% was observed for patients having the conformal therapy compared to conventional for the same fractionation. The majority of this cost arises due to the difference in treatment costs due to the repetitive nature of this process, the costs being incurred 32 times. The larger difference in costs between conformal and non-conformal therapy however occurs in the preparation for treatment, in particular the planning and volume placement costs where although the equipment and personnel involved are the same the complexity of the conformal treatment requires more time to achieve a satisfactory outcome.

The planning process also identifies a cost differential between the two treatment methods, conformal planning being cheaper than non-conformal. This however is a false statement in that the cost of the CT scanner has not been included because this cost does not come out of the departmental budget. If we include the CT cost that was established to be in the order of £220 for a procedure of this complexity; then the localisation of the conformal process is more expensive

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than that for non-conformal. The percentage difference in treatment costs between non-conformal treatment and conformal treatment, if the CT cost is included is 15% and 25% depending on the fractionation schedule.

The cost of a transurethral prostatectomy has been quoted as being between £1381 and £1817,[10] (figures have been converted to 1999 figures using the retail price index-Headline rates[11]) depending on complexity. Using the average of these figures as a comparison to the cost of radiotherapy it can be seen that radiotherapy costs approximately 55% more for conventional radiotherapy and 95% more for conformal therapy. However, one must bear in mind a number of factors when comparing these costs. Firstly the cost centre and costing methodologies were different and secondly the patient morbidity is known to be different for the two types of treatment.

CONCLUSION

The determinants of total treatment cost (time, machine type and staffing levels), do show significant variation between conformal and conventional treatment for cancer of the prostate. The cost for conformal treatment is either 8.5% or 20% higher than that for conventional treatment, depending on the fractionation schedule utilised (this excludes CT costs). Although the cost difference is relatively small, with the ever increasing concern about value for money within the health service, conformal treatment of the prostate must be shown to have a clinical benefit over conventional radiotherapy treatment in order to justify this increase in cost.

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