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Cost Analysis of Early Trabeculectomy versus Conventional Management in Primary Open Angle Glaucoma

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Summary

The financial cost of managing primary open angle glaucoma by trabeculectomy at diagnosis was compared with the cost of a more conventional sequence of medical therapy followed by trabeculectomy only in unsuccessful cases. Costs were estimated at 1989 prices for 104 patients studied in a prospective randomised multicentre trial which had been running for eight years. Separate estimates were made for operative costs, inpatient costs, and outpatient costs including visual field tests and medications. Values were adjusted to allow for the observed mortality rate within the group.

Conventionally managed patients with bilateral glaucoma required an average total expenditure of £2,570 for the eight year period, compared with £2,560 for those treated by early surgery. In both groups expenditure was greatest in the first year of care, and declined over the eight years. Although early surgery incurred a higher cost within the first year, in subsequent years the conventionally managed group was consistently more expensive and so overall costs were similar. Inpatient care was the most expensive item in both groups (62% of total cost in conventional management, and 77% with early surgery).

Our current practice is to admit patients for a shorter period than the average of 7.6 days at the time of this trial. We have therefore produced cost estimates based on a shorter inpatient stay of one and four days per operation, and in both cases early surgery becomes the less expensive strategy.

The results have been presented in a form that allows substitution of regional and temporal variations in costs and medical practice.

There is little information about the cost of eye care in Britain. Cost analyses of keratoplasty[1] and ocular trauma[2] have been undertaken, but no published information exists for glaucoma care. In the USA the importance of cost efficiency in glaucoma care has been stressed,[3,4] but no detailed analysis has been published. For France, Wolmark estimated the national cost of therapy for, and disability produced by, glaucoma,[5] but his data were derived from national statistics with no indication of cost per patient.

A recently published clinical trial has demonstrated the benefit of early trabeculectomy in the managment of open angle glaucoma.[6,7] However, concern has been expressed about the financial implications of adopting an early surgery policy. This study establishes the difference in costs between a conventional and an early surgery policy, as

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Table I *Patient groups. The 104 patients studied can be divided into 4 groups according to the randomisation to early surgery or conventional management, and whether one or both eyes fulfilled the trial criteria at the time of entry*

	No. of Patients		
	Unilateral glaucoma	*Bilateral glaucoma*	*Total*
Group A Conventional Management	23	30	53
Group B Early surgery	23	28	51
Total	46	58	104

well as exploring the general pattern of expenditure in glaucoma care.

Patients and Methods

Retrospective information was obtained from records of patients in a previously reported trial.[6,7] The patients were under the care of eight consultant ophthalmologists in five hospitals in the Glasgow area. All were consecutive and previously undiagnosed cases of primary open-angle glaucoma. Patients were accepted if the untreated intraocular pressure was 26 mmHg (Goldmann) or more on two occasions and if field defects characteristic of glaucoma were present. They were allocated to one of two treatment groups by means of a table of random numbers.

Group A was treated conventionally. Group B had trabeculectomy as soon as possible. The only intervention imposed by the trial was that of the random allocation as described above. Subsequent management including operation was the responsibility of the referring ophthalmologist. There were 116 patients in the trial but four refused early surgery, the case records of two patients were untraceable, and six patients had been lost to follow-up. Therefore, 104 were available for this analysis. These patients were assigned to two further groups according to whether one or both eyes fulfilled the entry criteria outlined above. Thus the 104 patients were divided into four groups of approximately equal size (Table I).

The major categories of National Health Service expenditure were identified and a cost was calculated for each (Table II). The cost of inpatient care and an outpatient attendance were obtained from Scottish Health Service statistics[8] and informal enquiry into patient costs at English Eye hospitals suggested similar values. Visual field costs were estimated on time required for manual bowl perimetry or Friedmann field analysis in glaucoma patients. These instruments were almost exclusively used for field assessment in the trial. Drug costs[9] were calculated assuming full patient compliance and the use of one

Table II *Cost Assumptions. These were used in conjunction with the data in Table III to calculate the costs incurred during glaucoma treatment. Drugs were charged at trade price with the addition of the NHS dispensing fee*

Item	*Cost (£)*
Inpatient Day	140
Outpatient attendance	20
Field test	5
Theatre cost per operation	95

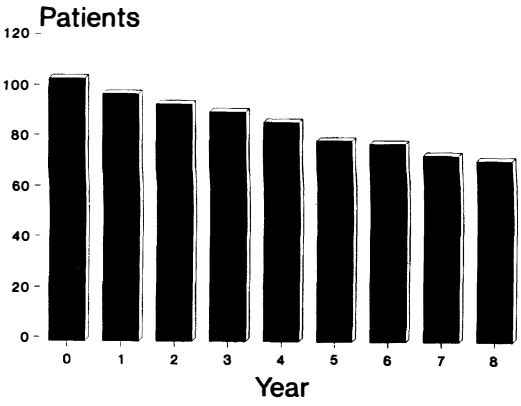

Fig. 1. *Histogram of patient survival. Costs were reduced to allow for the observed mortality.*

Table III *Resource utilisation. Showing mean number of items per patient for each category in each successive year for group A (conventional management) and group B (early surgery)*

Item	*Group*	*Year* 1	2	3	4	5	6	7	8
(a) Bilateral cases									
No. of drug	A	17.0	15.4	16.1	13.4	13.1	13.9	14.4	15.4
items per year	B	2.9	4.6	4.6	6.0	5.4	5.1	6.5	8.3
Outpatient	A	7.3	4.8	3.5	2.9	2.6	2.9	2.3	2.2
attendances	B	6.0	2.7	2.6	2.8	2.3	2.0	1.8	1.7
Field tests	A	3.0	2.1	1.7	1.6	1.3	1.4	1.4	1.0
	B	2.2	1.6	1.5	1.4	1.3	1.0	0.9	1.0
Operating	A	0.70	0.33	0.15	0.04	0.0	0.12	0.18	0.0
theatre visits	B	2.0	0.0	0.0	0.07	0.0	0.0	0.0	0.0
Inpatient days	A	6.0	3.0	1.0	0.16	0.0	0.88	1.2	0.0
	B	14.3	0.0	0.0	0.6	0.0	0.0	0.0	0.0
(b) Unilateral cases									
No. of drug	A	18.0	16.7	15.8	14.8	11.8	11.0	10.8	9.0
items per year	B	4.1	5.4	5.3	3.7	3.5	4.2	2.3	0.0
Outpatient	A	6.8	3.4	3.9	3.5	2.9	2.4	2.3	2.3
attendances	B	6.0	2.7	2.5	2.6	2.2	2.1	1.9	1.0
Field tests	A	2.3	1.8	1.6	1.9	1.5	1.4	1.4	1.5
	B	2.5	2.0	1.8	2.0	1.6	1.6	1.6	1.0
Operating	A	0.4	0.1	0.22	0.06	0.06	0.0	0.0	0.0
theatre visits	B	1.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Inpatient days	A	3.9	0.8	1.6	0.5	0.4	0.0	0.0	0.0
	B	9.9	0.8	0.7	0.0	0.0	0.0	0.0	0.0

bottle of each topical medication per month per patient. The drug cost included a pharmacists' Health Service prescription fee which added 6% to the total drug bill, 1989 prices were used and no adjustment was made for inflation. Expenses for cataract surgery or non-ophthalmic complications of therapy have not been included in the total costs, but the rate of cataract formation or extraction was the same in groups A and B.[6]

For each year of follow up the mean costs per patient per year for inpatient days, operations, outpatient attendances, field tests and drugs were obtained by review of the case records. An adjustment for mortality was applied to these costs using survival data for the trial patients over the eight years of the study (Fig. 1). For example, the cost per patient in year five was reduced by 12% as 12% of the patients in the trial had died by the beginning of their fifth year in the trial. In this manner a prospective cost per patient for a glaucoma population was derived and this adjusted cost was used rather than an average cost per survivor.

Data were entered on an Amstrad PC1640 microcomputer running a Framework (Ashton-Tate) spreadsheet, and mean costs per patient year for outpatient and inpatient care were calculated.

The effect of reduced inpatient stay on cost was investigated by modification of existing data as if there had been either an average one day (24 hours) admission or four day admission. The resulting cost estimates were compared with those seen in the trial patients.

Results

Table III shows the mean number of inpatient days, outpatient attendances, theatre visits, drug items and field tests per patient for each year following diagnosis. Table IV presents the mean costs per patient for the same items over the eight year period following diagnosis. It can be seen that the mean costs in the bilateral group were higher than those of

Table IV *Mean expenditure (£) per patient by category of resource item for each year. Sums derived from Tables II and III, adjusted for mortality*

Item	Group	Year 1	2	3	4	5	6	7	8
(a) Bilateral cases									
Drop cost	A	60.8	52.8	51.9	47.8	49.8	47.7	47.4	51.9
	B	11.6	17.0	13.0	19.9	18.1	21.9	26.0	28.4
Tablet cost	A	1.3	3.2	0.0	0.0	0.0	0.0	0.0	0.0
	B	3.6	2.8	2.8	2.5	0.9	0.0	0.0	0.0
Total NHS	A	70.5	63.7	59.9	54.5	56.3	54.7	54.6	59.6
drug cost	B	16.6	22.1	18.1	25.4	21.8	24.5	29.3	32.6
Field cost	A	15.2	10.4	8.4	7.8	6.7	7.1	6.8	5.0
	B	10.9	8.0	7.5	7.0	6.5	5.0	4.3	5.0
Outpatient	A	145.8	95.6	70.4	57.6	52.4	58.8	45.4	44.0
visit cost	B	120.0	54.0	52.0	56.0	45.8	40.0	35.4	34.0
Total	A	231.5	159.8	125.3	104.9	96.5	92.4	80.6	77.2
Outpatient cost	B	147.5	79.2	70.2	77.4	62.0	53.2	52.0	50.9
Total	A	794.8	353.1	153.9	39.7	0.0	104.4	154.3	0.0
Inpatient cost	B	1909.6	0.0	0.0	58.5	0.0	0.0	0.0	0.0
(b) Unilateral cases									
Drop cost	A	65.2	62.1	58.9	52.9	50.8	47.5	48.8	44.7
	B	16.3	27.8	24.5	14.0	16.7	19.3	12.0	0.0
Tablet cost	A	8.2	9.9	21.5	11.1	7.6	6.4	7.6	0.0
	B	0.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total NHS	A	82.3	80.3	88.3	71.4	64.3	59.4	61.9	49.2
drug cost	B	18.4	30.5	27.1	15.9	18.4	21.5	13.2	0.0
Field cost	A	11.5	8.8	8.0	9.5	7.5	7.0	7.0	7.5
	B	12.7	9.8	8.8	10.0	7.9	7.9	7.9	5.0
Outpatient	A	135.0	67.0	78.8	70.0	58.8	48.4	46.0	45.0
visit cost	B	20.8	53.4	50.0	52.6	43.6	41.4	37.2	20.0
Total	A	228.8	147.0	158.3	132.0	109.2	88.0	86.7	72.3
outpatient cost	B	151.8	88.2	77.6	68.7	58.5	54.2	44.0	17.8
Total	A	451.4	106.3	224.4	59.2	56.6	0.0	0.0	0.0
inpatient cost	B	1378.0	102.2	98.1	0.0	0.0	0.0	0.0	0.0

patients presenting with only one eye that fulfilled the trial entry criteria. However, the mean cost of care for bilateral cases was less than twice that of the unilateral cases, partly because some patients in the unilateral group later required treatment in the fellow eye.

In the bilateral group, the total cost per patient over an eight year period (Table IV) was almost identical for group A (£2,568.62: conventional management) and B (£2,560.48: early surgery). Patients presenting with unilateral disease showed a slightly lower cost when managed conventionally: £1,920.22 compared with £2,138.99 for early surgery.

Figure 2 compares the timing of expenditure for the bilateral cases in groups A and B. Both incurred the greatest expense during the first year, and the mean expenditure in group B in this first year was approximately twice that of the conventional group A. However, group A engendered the greater cost for each of the succeeding seven years of follow-up.

Figure 3 illustrates the distribution of expenditure in the bilateral cases of groups A and B. It can be seen that group A incurred increased inpatient costs compared with group B as more operations were performed. However, more expenditure was required for drugs, outpatient attendance and field testing in group B which compensated for the disparity in inpatient costs.

Costs were reassessed for shorter periods of

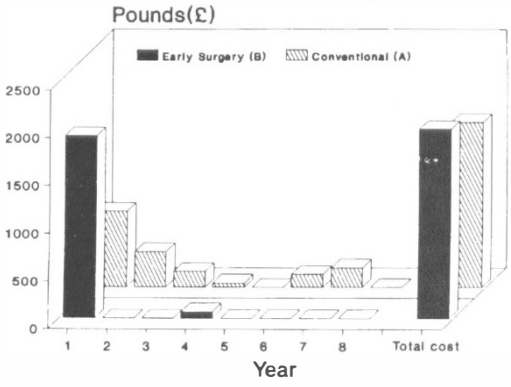

Fig. 2a.

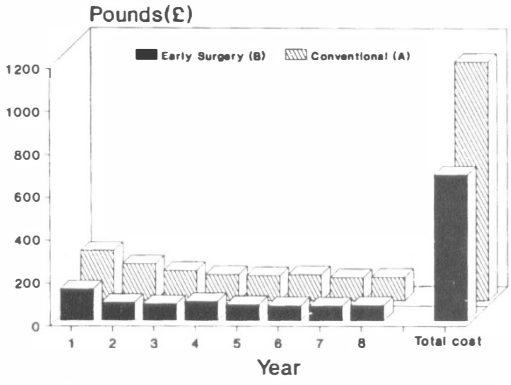

Fig. 2b.

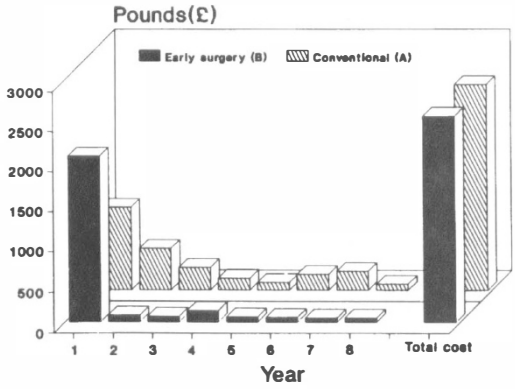

Fig. 2c.

Fig. 2. *Mean costs per patient incurred each year following diagnosis of glaucoma. Figures are for the bilateral cases of group A (conventional management) or group B (early surgery). (a) Mean Inpatient Costs. (b) Mean Outpatient Costs. (c) Mean Total Costs.*

inpatient stay by modification of the data for bilateral cases in Table III and IV. It was estimated that a one-day admission for surgery would incur £95 theatre costs, £125 ward costs, and £100 costs for additional outpatient attendances with transport. A four day admission was estimated to produce £95 theatre costs, and £500 ward costs. For the one day admission cost reductions of 45% for the conventional group A and 56% for the early surgery group B were predicted. For a four day admission group A costs decreased by 27% and group B by 30% (Figure 4).

Discussion

We have presented the pattern of expenditure encountered over the eight-year period following diagnosis of open angle glaucoma. Values obtained from hospitals within the Strathclyde region[8] (Table II) have been used to calculate costs of in- and out-patient care, but many hospitals will soon have locally-derived data,[10] and so we have presented the required information to allow substitution of alternative cost assumptions (Table III).

Only the direct aspects of glaucoma care

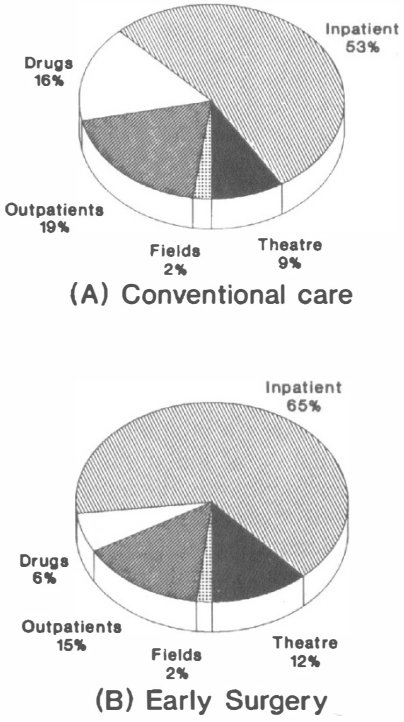

Fig. 3. *Pie chart illustrating the pattern of expenditure in the bilateral cases undergoing (A) conventional management or (B) early trabeculectomy.*

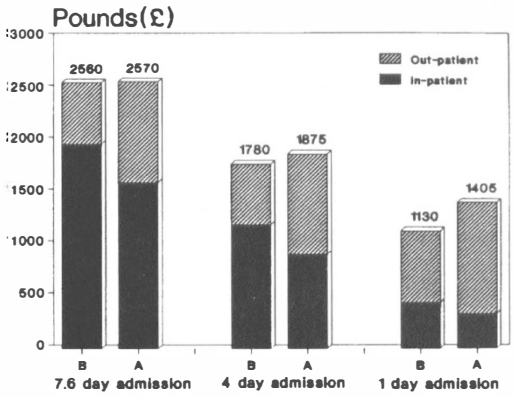

Fig. 4. *Projected costs for bilateral cases based on shorter inpatient admissions of four days or one day per operation. It can be seen that a considerable reduction in cost occurs if a reduced stay in hospital is employed. An early surgery policy (B) becomes more cost-effective than conventional care (A) when the inpatient stay is reduced.*

and its ophthalmic complications were considered. No account was made to cost disability from the disease and a cost-benefit analysis was not attempted. It has, however, been shown that there is a significant benefit for the early surgery group in preservation of visual field.[6,7] In this study Argon laser trabeculoplasty was used twice and automated perimetry was performed very infrequently. Therefore no attempt was made to include extra costs for these items. They may be expensive options[11] and would require inclusion in cost analyses for units where such techniques comprise a large component of glaucoma management.

The calculation of costs adjusted for mortality favoured the conventional management group. In the early surgery group nearly all the inpatient costs occurred in the first year and so were little reduced by allowance for mortality. By comparison, in the conventional management group inpatient, and indeed all costs, spread into later years and therefore underwent a greater reduction by mortality adjustment. Eliminating the effects of inflation will also have favoured the conventional group for similar reasons.

It might be argued that the cost assumptions used in this study were not sufficiently comprehensive. For instance, no consideration has been given to patient transport costs, general practitioner duties, or patient compliance. These would be difficult to quantify and would probably have contributed little to overall costs. Perhaps the greatest uncertainty derives from the use of Health Service statistics,[8] notably those relating to inpatient care. With the introduction of diagnosis-related group (DRG) statistics,[10] more reliable estimates should be obtainable soon.

Using keratoplasty data from a previous cost analysis by Menage *et al.*[1] we have been able to compare the costs of glaucoma surgery and keratoplasty. They presented data for three years of follow-up and therefore we have restricted costs of glaucoma treatment to the same period. Identical cost assumptions (Table II) were substituted for both groups of patients and the resulting comparison is shown in Figure 5. At £2,210 over 3 years bilateral glaucoma surgery is less expensive than unilateral keratoplasty, which was estimated to cost £3,750.

Concern has been expressed that a widespread change towards a policy of early trabeculectomy would result in a substantial increase in expenditure on glaucoma care. We have now demonstrated that there is no cost increase for a patient with bilateral glaucoma,

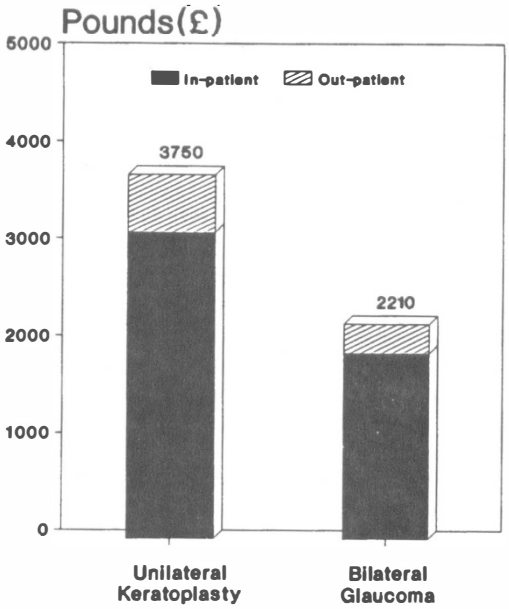

Fig. 5. *Three year cost comparison of penetrating keratoplasty and bilateral glaucoma surgery. It can be seen that the cost of unilateral keratoplasty is the greater.*

and that the costs of a patient who presents with unilateral glaucoma would be only marginally increased if early surgery were performed. Many of the fellow eyes in the unilateral group of patients went on to develop ocular hypertension or glaucoma at a variable interval following entry into the trial, and it was not possible to separate the costs of review and therapy for each eye with any accuracy. Therefore we have devoted most of our analysis to the data from the more homogeneous bilateral group.

The minimal difference in total expenditure between groups A and B masks a marked alteration in the composition of this total sum (Fig. 3). With early trabeculectomy there is a reduced requirement for all aspects of outpatient care, balanced by a 30% increase in inpatient costs. The greatest change is seen in pharmaceutical expenditure, which is reduced by over 60%.

The few days spent as an inpatient produced greater than 50% of the total expenditure. The medical staff responsible for the care of the patients in the study were surprised to learn that the average inpatient stay was as long as 7.6 days per operation. However, the average inpatient stay per operation in those randomised to bilateral early surgery was only 6.8 days, as a majority of the patients underwent surgery to both eyes during the same admission. Minor postoperative problems such as a small hyphaema or mild shallowing of the anterior chamber were the commonest causes of admissions of greater than one week. With the improved surgical technique and more confident postoperative care that is appearing with greater use of trabeculectomy, patients are now in hospital for a shorter period. Figure 5 illustrates the hypothetical costs of a patient staying in hospital one night or four nights per operation. It can be seen that a considerable saving is engendered in both groups A and B, and that the early surgery option becomes more cost efficient than a conventional approach when a shorter hospital stay is adopted. An emphasis on admission length in cost efficiency has been criticised in general surgery as the costs of preoperative assessment and the operation itself can be considerable.[12] The same argument does not apply to most elective ophthalmic operations which require relatively little preoperative assessment and theatre time. It is our current practice to admit patients for about four days per operation, and a one day admission is theoretically possible. These shorter admissions produce a cost advantage for an early operation strategy, and if they can be generally employed without increased postoperative complications will significantly reduce the overall cost of glaucoma care.

Key words: Cost Analysis, Primary Open Angle Glaucoma, Early Trabeculectomy

References

[1] Menage MJ and Claoué CMP: Severe herpetic keratitis. The costs associated with penetrating keratoplasty. *J Roy Soc Med* 1988, **81:** 526–7.
[2] Keightly SJ: Serious eye injuries from windscreen contact. *J Roy Soc Med* 1983, **76:** 911–6.
[3] Quigley HA: Re-evaluation of glaucoma management. *Int Ophthalmol Clin* 1984, **24:** 1–11.
[4] Spaeth GL: New technology—new pressures. *Ophthalmic Surgery* 1988, **19:** 617–20.
[5] Wolmark: le coût socio-économique du glaucome. *Rev Int Trach Pathol Ocul Trop Subtrop Sante Publique* 1983, **2:** 127–42.
[6] Jay JL and Murray SB: Early trabeculectomy versus conventional management in primary open angle glaucoma. *Br J Ophthalmol* 1988, **72:** 881–9.
[7] Jay JL and Allan D: The benefit of early trabeculectomy versus conventional management in primary open angle glaucoma relative to severity of disease. *Eye* 1989, **3:** 528–35.
[8] Common Services Agency: Scottish Health Service Costs, 1988/89 edition, Edinburgh: CSA, Scottish Office, 1989: 37–61.
[9] Chemist and Druggist, Monthly Price list, Tonbridge: Benn Publications May 1989 Vol. 30, no. 5.
[10] Mills I: Resource Management Initiative: Information. London: Dept of Health March 1989.
[11] Quigley HA and Hitchings RA: Personal Communications. Glaucoma group meeting, London, November 1989.
[12] Lannin DR: Length of hospital stay for routine surgery. *Arch Surg* 1987, **122:** 120–1.