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Immediate computed tomography or admission for observation after mild head injury: cost comparison in randomised controlled trial

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Abstract

Objective To compare the costs of immediate computed tomography during triage for admission with those of observation in hospital in patients with mild head injury.
Design Prospective cost effectiveness analysis within a multicentre, pragmatic randomised trial.
Setting 39 acute hospitals in Sweden
Participants 2602 patients (aged ≥6) with mild head injury.
Interventions Immediate computed tomography or admission for observation.
Main outcome measures Direct and indirect costs related to the mild head injury during the acute and three month follow-up period.
Results Outcome after three months was similar for both strategies (non-significantly in favour of computed tomography). For the acute stage and complications, the cost was 461 euros (£314, $582) per patient in the computed tomography group and 677 euros (£462, $854) in the observation group; an average of 32% less in the computed tomography group (216 euros, 95% confidence interval −272 to −164; P<0.001). Sensitivity analysis showed that computed tomography was the most cost effective strategy under a broad range of assumptions. After three months, total costs were 718 euros and 914 euros per patient—that is, 196 euros less in the computed tomography group (−281 to −114; P<0.001). The lower cost of the computed tomography strategy at the acute stage thus remained unchanged during follow-up.
Conclusion Patients with mild head injury attending an emergency department can be managed more cost effectively with computed tomography rather than admission for observation in hospital.
Trial registration ISRCTN81464462.

Introduction

The use of immediate computed tomography during triage for patients with mild head injury, rather than admission, is feasible and clinically similar in outcome compared with observation in hospital.[1] Model based studies also suggest that the computed tomography strategy is a third cheaper.[2] We undertook a cost effectiveness analysis to test whether such a strategy reduces costs in managing mild head injury at the acute stage and, if so, whether the reduced costs remain after the three month follow-up period.

Methods

Study design

The study had two parts, one on medical outcome and one on costs. Power calculations were performed for the first part. Though a much smaller study would be needed to detect the expected difference of around 30% of cost between the methods, we extended the cost analysis to the whole study.

In total, 2602 patients (aged ≥6) were randomly assigned to computed tomography (n=1316) or observation in hospital (n=1286). Emergency departments at 39 hospitals throughout Sweden recruited consenting patients from May 2001 through January 2004. Inclusion criteria for the study were mild head injury defined as loss of consciousness or amnesia, or both; normal score on the Glasgow coma scale (15 points); and normal neurological findings on arrival after the head trauma. The two groups of patients were similar at baseline as regards age, sex distribution, and time from trauma to randomisation. The figure shows the flow of participants through the study. The analysis of outcome data was by intention to treat. Of the 1316 patients allocated to computed tomography, 1292 received it and 117 were admitted for observation; and of the 1286 patients allocated to observation in hospital, 1220 were admitted and 111 also had computed tomography. We assessed survival, functioning, and wellbeing after three months using the extended Glasgow outcome scale (GOS-E).[3] The number of patients who had not fully recovered (GOS-E 1-7) was similar for the two strategies of care, even when only the worst outcomes were considered.

Data collection

Researchers prospectively registered the time of trauma, arrival, computed tomography, admission, discharge, and use of resources in the case report form for each patient. They also prospectively registered clinical course—that is, complications, change in care, and treatment. At follow-up after three months, we posted questionnaires to explore outcome (assessed by the extended Glasgow outcome scale) and included questions on outpatient care, inpatient care, and sick leave from work because of the injury. After reminders and telephone calls, the response rate was 97%. In the remainder we checked survival and hospital care through official registers.

P+ *The details of investigators, committee members, and other study personnel are on bmj.com.*

Table 1 Mean costs (€) for computed tomography at 57 regional/university, county, and local hospitals in Sweden

Type of hospital	Mean (1st and 3rd quartiles)
Office hours	
University/regional (n=9)	176 (142-182)
County (n=21)	161 (138-179)
Local (n=27)	158 (138-176)
Out of office hours	
University/regional	229 (155-269)
County	216 (160-259)
Local	198 (144-228)

Table 2 Daily costs (€) for care in a surgical ward at 28 regional/university, county, and local hospitals

Type of hospital	Total/day	Mean cost for room and board (1st and 3rd quartile
University/regional (n=5)	811	494 (462-515)
County (n=10)	638	389 (357-427)
Local (n=13)	572	349 (328-361)

Costing

The Swedish healthcare system is based on administratively and financially independent county councils and municipalities. Every hospital in Sweden, regardless of its category or size, has responsibility for basic medical and surgical care within a defined primary catchment area. The hospitals are university/regional, county, or local. We compared costs of two alternative management strategies from a societal perspective. Use of resources was translated into costs by use of average costs based on accounting data in official statistics from the county councils.

All patients had an outpatient visit to the emergency department—that is, the same cost for both groups. Differences of costs appeared after the allocation to computed tomography or observation in hospital. The cost of one scan was based on a survey of 57 Swedish hospitals.[4] The arithmetic mean cost for each hospital category was calculated for office hours (Monday-Friday, 7 am-5 pm) and out of office hours (all other hours and weekends). The lower rate of use during nights and weekends increases the cost per examination. We individually assigned costs of computed tomography depending on the time of examination and the category of hospital (table 1).

The cost of observation in hospital was also individually assigned and was defined as the cost for room and board[5] best corresponding to resources used by patients with mild head injury. It includes staff salaries, costs of housing, and drugs but excludes costs for surgery, intensive care, radiology, or laboratory analyses. We could not get relevant accounting data from every included hospital so we used mean costs from several hospitals at each level. Financial reports from 28 Swedish hospitals in 1978, 1988, and 2002 showed that the structure of costs was steady over time. Room and board constituted about 60% of the average cost per day (61% in 2002).[6] We therefore multiplied the mean cost per day on surgical wards at regional/university, county, and local hospitals by 0.61 to achieve the cost for room and board (table 2).

For the follow-up period we collected itemised costs for health care from county council estimates and statistics (table 3). Indirect costs were defined as the estimated loss in production (excluding students) caused by days of absence from work, including that of parents as a result of injury in a child, and were calculated individually. Cost for absence was calculated as the average daily labour cost, payroll taxes included, and stratified for sex and age, for patients aged <65.

We have expressed all costs at 2003 prices and inflated cost data from earlier years to 2003 with the Swedish price index for wages and for county councils.[10 11] Costs were not discounted as the follow-up time was limited to three months. We converted costs in Swedish kronor (SKr) to euros adjusted for purchasing power parity at the rate of 1 SKr = €0.092—that is, the average for 2003 (the exchange rate of euro *v* SKr increased 1.75% from 2003 to 2005).[12]

Statistical analysis

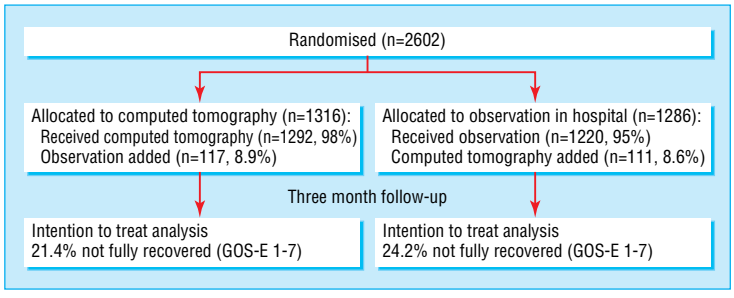
We compared costs between the two treatment strategies for arithmetic mean costs, as suggested for pragmatic randomised trials.[13] The *t* test for independent groups, modified for unequal variances, is often used but requires approximately normal distributions. However, if the data are not normally distributed, the *t* indicator can be used by means of a bootstrapping technique and thereby reliable P values and confidence intervals can be achieved.[14 15] Hence, we applied naive groupwise bootstrapping (that is, imputing the mean of the observed values for each missing observation) with n = 1000 resampled estimates. For a sensitivity analysis, we use the first and third quartile costs for the two most important cost drivers—that is, cost for computed tomography and cost for observation in hospital at hospitals in the three categories

Results

Acute stage and complications

For patients randomised to the computed tomography strategy, the total cost during the acute stage was €607 704 (table 4), or €461 per patient (table 5). For patients admitted for observation the corresponding figures were €869 743 or €677 per patient. Hence, the average cost per patient was 32% or €216 less in the computed tomography group (95% confidence interval −272 to −164; $P<0.001$). The sensitivity analysis showed the difference to be at least €189 (first quartile cost) and at most €279 (third quartile cost) per patient.

Costs for complications and readmissions are included in the above figures. Four neurosurgical operations for subdural



Flow of participants through study and the medical results

Table 3 Other specified costs expressed as mean values (€)

Type of costs	Cost
Emergency ward visit	194[7]
Primary care visit	110[8]
Neurosurgical operation for subdural haematoma and care	6072[6]
One neurosurgical day	1564[7]
Neurosurgical consultation	55[7]
Sickness absence, average salary/day (20-65 years, 10 year age groups)	69-120 (women); 96-172 (men)[9]

haematoma (one in the computed tomography group and three in the observation group) were performed among all 2602 patients. A similar number of days of observation on a neurosurgical ward and days of readmittance for sequelae were needed in both groups. The computed tomography strategy generated more neurosurgical consultations, mostly by telephone. Because there were few complications, their contribution (neurosurgical consultation, operation and care, and observation) to the total cost per patient was limited to €26 in the computed tomography group and €36 in observation group.

Follow-up

During the three month follow-up period the cost for the computed tomography group was €337 943 *v* €305 596 for the observation group (table 4). This corresponds to a cost per patient of €257 *v* €237 (table 5).

Total cost

The total average cost of the acute stage, including complications, was €718 per patient for the computed tomography group *v* €914 per patient for the observation group (table 5), a difference of €196 (95% confidence interval −281 to −114; $P<0.001$). Sensitivity analysis, based on the first and the third quartiles, respectively, showed a difference from €185 to €214 per patient in favour of the computed tomography strategy.

Table 5 Cost per patient (€) for computed tomography *v* observation in hospital (€)

	Computed tomography	Observation in hospital	P value
Mean cost during acute stage and complications (1st and 3rd quartile)	461 (354-490)	677 (543-688)	<0.001
Mean cost during follow-up	257	237	
Total	718	914	<0.001

Hence, the lower cost of the computed tomography strategy in the acute stage remained largely unchanged during the follow-up period.

Discussion

Patients with mild head injury can be managed more cost effectively with a computed tomography strategy instead of admission for observation at the acute stage. The computed tomography strategy costs €196 less per patient. The difference was robust for sensitivity calculations based on the main influences on cost.

We had accounting data for 28 of the 75 Swedish hospitals, including several in each of the three hospital categories. The prevalence of patients in this study treated within each category of hospital was similar to that of all patients admitted for mild head injury in Sweden and so was the age and sex distribution. Thus, the calculations of costs for admission, one of the main cost influences, seem to be reliable and representative of the actual costs for this group of patients. We also looked at consumption of resources so we could include more unusual local costs in the comparison between strategies.

The other principal cost was that of computed tomography, which we based on information from 58 of the Swedish hospitals. Around 70% of all investigations were performed outside office hours, for which there is a higher cost per

Table 4 Total use of resources (numbers of patients unless stated otherwise) and costs for computed tomography *v* observation in hospital during acute stage and follow-up

	Resource use		Total costs (€)	
	Computed tomography (n=1316)	Observation in hospital (n=1286)	Computed tomography	Observation in hospital
During acute stage and complications				
Emergency ward visits	1316	1286	254 663	248 857
Computed tomography:			243 980	20 473
Total	1292	111		
Office hours	668	67	109 726	10 893
On duty	624	44	134 254	9 580
Days in hospital:				
Total	183	1359	74 805	552 965
University/regional	57	362	28 170	178 901
County	66	648	25 691	252 239
Local	60	349	20 944	121 824
Neurosurgical operation and care	1	3	6 072	18 216
Days under neurosurgical observation/in intensive care	17	17	26 583	26 583
Days of readmission	1	5	389	2 263
Neurosurgical consultations	22	7	1 212	386
Subtotal			607 704*	869 743*
Follow-up				
Primary care visits	121	158	13 329	17 404
Emergency ward visits	104	91	20 125	17 610
Sickness absence†	2659.25	2331.75	304 489	270 582
Subtotal			337 943	305 596
Total			**945 647***	**1 175 339***

*P<0.001 for difference.
†Full time equivalent days.

examination. Still, comparison of the average cost for computed tomography in this study with that of observation—that is, €197 *v* €403—showed a margin of about 100% before the average cost for computed tomography reached the cost for room and board.

International comparison of cost data

A study in the Netherlands showed that nursing costs account for 32% to 64% of the total cost for a day in hospital.[16] In the same study, the joint costs of overheads, equipment, accommodation, and housekeeping were 22% to 30% of the total cost. The ratio of average daily costs of hospitals in different categories also resembled that of Swedish hospitals. Hence, the cost structure used for calculation of observation in hospital in this analysis is also found in other countries.

We found that using computed tomography rather than admission for observation in the acute phases reduced costs by about 32%. This is comparable with estimates from model studies in the United States, Spain, and Norway.[17–19] Our own decision tree analysis based on Swedish hospital data showed similar results, suggesting a cost reduction of 36%.[2]

About 17 000 people with mild head injury are admitted to hospital each year in Sweden, equivalent to about 175/100 000 inhabitants.[20] In about 22% of cases, current clinical management includes computed tomography.[21] Out of 17 000 patients, around 15 000 are aged ≥6 years—that is, the age groups included in our study. If the computed tomography strategy were to be implemented, there would be a yearly increase in demand of about 130 scans per 100 000 inhabitants (two to three a week at an emergency department serving 100 000 inhabitants). Such an increase seems possible to handle within the present capacity for computed tomography in Sweden. The savings of about 165 days of hospital stay (three to four a week) per 100 000 inhabitants could be used for other patients for whom there is a shortage of bed days. A similar decrease in admissions in hospital by introduction of the computed tomography strategy has been estimated for the United States.[22]

Observation in hospital will probably always be necessary for some patients, such as elderly people living alone. For others, the computed tomography strategy represents positive value for patients, with the opportunity to receive medical assurance and to be discharged several hours earlier. For most patients with mild head injury, this represents a satisfactory and cost effective treatment option.

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Ethical approval: The study was approved by all regional ethics committees in Sweden.

What is already known on this topic

Costs for acute care of patients with mild head injuries are considerable

Model calculations indicate that use of computed tomography during triage for admission would be less expensive than admission for observation

What this study adds

Computed tomography is more cost effective for acute care of patients with mild head injury, being about a third less expensive than admission for observation

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