For Debate

Retrospective study of 1000 deaths from injury in England and Wales

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Abstract

One thousand consecutive deaths from injury in 11 coroner's districts in England and Wales were reviewed by four independent assessors, who studied necropsy reports to identify deaths in hospital that might have been preventable. Of 514 patients admitted to hospital alive, 102 deaths (20%) were judged by all four assessors to have been potentially preventable. When those cases in which three out of four assessors considered that the death was preventable were added the total rose to 170 (33%). Nearly two thirds of all non-central nervous system deaths were judged to have been preventable. The median age of the 170 patients whose deaths were preventable was 41, and the mean Injury Severity Score was 29. Further analysis suggested that the preventable deaths were principally the result of failure to stop bleeding and prevent hypoxia and the absence of, or delay in, surgical treatment.

The results closely parallel those from similar studies from the United States and suggest that there are serious deficiencies in the services for managing severe injury in England and Wales. Debate is needed now on how to correct these deficiencies. In particular, the place of trauma centres must be considered.

Introduction

In England and Wales injury remains the main single cause of death in both sexes between 15 and 34 years of age, exceeding the combined deaths from heart disease and cancer. It is the third commonest cause of death in all ages.[1] Since the end of the second world war committees have deliberated on how best to provide services for injured patients and have recommended differing solutions. Some of these have been implemented, and the creation of the specialty of accident and emergency medicine has had a major impact. Consultants in this specialty have now been placed in charge of most accident and emergency departments in the United Kingdom and the result has been a noticeable rise in the standard of care of patients attending these departments.[2]

Despite the undoubted benefits from accident and emergency medicine the results of studies in the United States suggest that the way most severely injured patients are managed still leaves much to be desired. These studies have led to the establishment of specialised units known as trauma centres. Such centres have round the clock cover by experienced surgeons and anaesthetists able to carry out major surgical procedures such as aortic cross clamping and hepatic venous bypass within minutes of a patient being admitted.

Trunkey and his colleagues studied two adjacent counties in the USA with different systems of trauma care to ascertain whether there were differences in outcome in the management of severely injured patients.[3] They showed that in the county in which the patients were taken to the nearest of 31 departments offering an emergency service the outcome was appreciably worse than in the adjacent county where all severely injured patients were taken to only one hospital with a trauma centre able to respond immediately to the needs of the severely injured. The improved outcome in the latter hospital arose from a combination of earlier recognition of life threatening injuries and the prompt institution of treatment by experienced surgeons and anaesthetists. The result of this study was the widespread, though not universal, establishment of trauma centres. The results of follow up studies show that where such centres have been established the results of treatment of severely injured patients have greatly improved.[4-6]

Because of different circumstances in the UK, in particular the lower incidence of serious personal assaults particularly with firearms, many have doubted whether the same problems exist. In view of the uncertainty and the lack of statistical information, the Royal College of Surgeons, through its Commission on the Provision of Surgical Services, established a working party to study the standard of care in the management of major injuries and to make recommendations.

The college funded a research assistant (MW) to enable a two part study of the outcome of major injury to be carried out. We report the first part, a retrospective study of deaths from injury. The commission decided to publish the results of the retrospective study now to stimulate debate about the management of injured patients in general and the role of trauma centres in particular.

Materials and methods

A retrospective study was carried out from the end of 1986 of 1000 consecutive deaths after injury in 11 coroner's districts in England and Wales. Deaths occurring after fracture of the neck of the femur in patients over age 65 were excluded. The coroner's districts were chosen to encompass metropolitan and provincial cities with and without universities, suburbs, towns, and rural areas (table I). One hundred deaths were studied in each of nine districts and 50 deaths in each of two smaller districts. The districts

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took between 11 and 39 months to accumulate the deaths. The population of the districts ranged from 128 300 to 1 110 900,[7] and the number of hospitals receiving the injured in each district ranged from one to five. Six districts contained hospitals with neurosurgical units, which received injured patients from outside their coroner's district; those without a neurosurgical facility sometimes transferred cases away from their coroner's district.

TABLE I—*Characteristics of 11 districts chosen for study*

District	Population 000s	No of hospitals receiving trauma patients	No of admissions	Time to accumulate data (months)	No of neurosurgical transfers: Into district	No of neurosurgical transfers: Out of district
(1) Metropolitan	192·6	1	77	33	24	—
(2) Provincial capital	497·3	5	68	32	23	—
(3) University city	394·8	1	62	24	24	—
(4) Industrial area	807·9	4	60	21	5	—
(5) University city	530·0	2	50	15	23	—
(6) Seaside town*	142·6	1	24	21	—	7
(7) Metropolitan suburb	1110·9	5	46	11	14	—
(8) Provincial suburb	357·6	2	45	26	—	6
(9) Rural town	128·3	1	36	39	—	7
(10) Provincial suburb	533·9	5	33	39	—	—
(11) Industrial town*	298·8	1	13	23	—	—

*50 consecutive trauma deaths collected in these districts.

In each case the pathologists' records, consisting of a clinical summary and a necropsy report, were obtained and analysed. Age, sex, time and nature of the accident, injuries sustained, treatment given, operations performed, and time and place of death were extracted for study. Those patients who died at the scene of the accident or were pronounced dead on arrival were separated from those who died after arrival at hospital. If any resuscitation or treatment was given at the receiving hospital the case was regarded as a hospital death. Deaths from injury of the central nervous system were separated from deaths from other injuries as indicated by the cause of death given by the pathologist.

Summaries of each patient's age, sex, injuries sustained, treatment given, and time to death were then sent to four independent assessors, all of whom were familiar with the American system of trauma centres. These assessors, three consultant surgeons (an academic, a specialist in trauma care, and a district general hospital surgeon) and one accident and emergency consultant, were asked to answer "yes" or "no" to the question: If this patient had been admitted to a fully staffed and equipped American style trauma centre might death have been prevented? The results were analysed, and particular note was taken of cases in which all four, or three out of four, assessors agreed that the death was potentially preventable.

A separate analysis of the cases considered by all, or three of the four assessors, to be preventable was then carried out. These were given an Injury Severity Score, as described by Baker *et al*,[8,9] by a trained scorer. Records were studied to establish whether haemorrhage or hypoxia might have contributed to death, as judged by injuries and findings at operation and necropsy. Haemorrhage was considered to be contributory when the injuries sustained were associated with appreciable blood loss, when a source of bleeding was not treated, or when the cause of death given was haemorrhagic shock. Haemorrhage affecting the central nervous system was excluded. Hypoxia was deemed to have been contributory when aspiration had occurred or a sudden hypoxic death occurred. Patients with multiple injuries (at least two body areas with Abbreviated Injury Scale ≥ 3 or at least three areas with AIS ≥ 2) were identified, as were deaths from pulmonary embolism. Apparently missed or untreated injuries, as shown by the lack of usual treatment for a given injury, were noted. With each such missed diagnosis an estimate was made of whether treatment might have altered the outcome in the light of the other injuries present. Injuries normally treated surgically were reviewed to ascertain if an operation had been undertaken and if it was unduly delayed or incomplete. Finally, the outcome of cases which presented to teaching hospitals was compared with those that presented to non-teaching hospitals.

Results

Of the 1000 consecutive deaths from injury, 707 (71%) were in males and 293 (29%) in females. The commonest age group affected were the early adult years, although there was a second peak in the eighth decade (fig 1). Nearly half (486) died at the scene of the accident or were certified dead on arrival at hospital, while the remainder (514) were admitted but died (hospital deaths). There was considerable interdistrict variation in the rate of deaths on arrival, ranging from 23/100 (23%) in a metropolitan area to 37/50 (74%) in an industrial town. Part of the difference can be explained by the inclusion of figures for neurosurgical tertiary referrals in those districts with neurosurgical units, which tends to lower the rate of those who were dead on arrival. That rate, however, exceeded half in six of the 11 districts (fig 2).

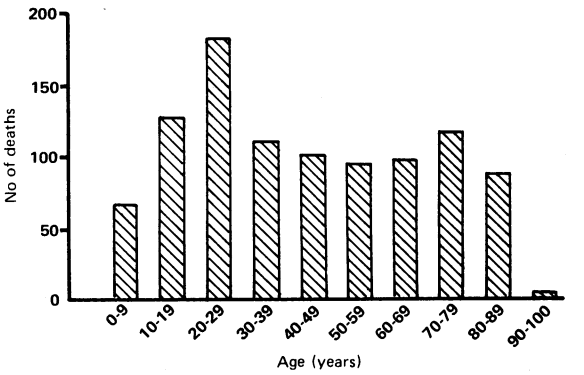

FIG 1—Age distribution of 1000 patients who died from severe injuries.

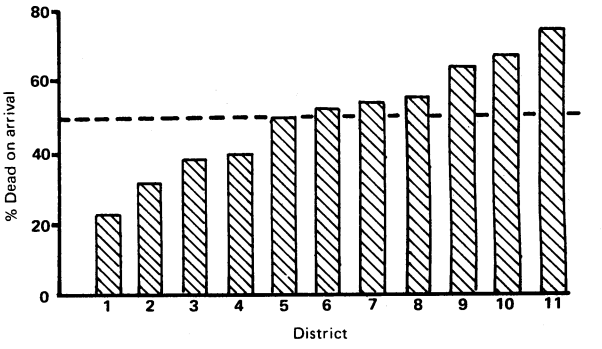

FIG 2—Percentage of patients who were dead on arrival at hospital in the 11 districts studied.

Injury to the central nervous system was the cause of death in 335 (65%) of the 514 patients admitted to hospital, the remaining 179 (35%) dying of causes not associated with the central nervous system.

Of these 514 deaths in hospital, 102 (20%) were independently judged by all four assessors to be preventable (table II). Seventy seven of these were not related to the central nervous system; the remaining 25 were. Thus, 43% of all deaths not related to the central nervous system and 7% of all deaths that were were judged preventable. The median age of the 76 men and 26 women in this category was 32 (range 3-84 years), and the average Injury Severity Score was 30.

TABLE II—*Preventability in 514 hospital deaths from severe injury*

No (%) of deaths judged preventable by 4 out of 4 assessors	102 (20)
No (%) of deaths judged preventable by 3 out of 4 assessors	68 (13)
No (%) of deaths judged preventable by 2 out of 4 assessors	68 (13)
No (%) of deaths judged preventable by 1 out of 4 assessors	90 (18)
No (%) of deaths judged non-preventable by 4 out of 4 assessors	186 (36)

When the 68 (13%) cases in which three out of four assessors considered the death to be preventable were added the total number of preventable deaths was 170. Of these 68 cases, 36 were not related to the central nervous system and 32 were, giving totals for those two groups of 113 (63%) and 57 (17%) respectively. These 170 cases (33% of all those reaching hospital alive) are hereafter referred to as "preventable deaths." It is notable that 102 (60%) of these deaths followed road traffic accidents.

As table II shows, and in common with other judgments in clinical medicine, the four assessors differed on occasion in their interpretation and judgment of the data provided, though all four were completely in agreement on 56% of occasions (a far higher proportion than would be

expected by chance), and there was a clear (3:1) majority in 87% of the cases. The kappa value for assessing agreement between each pair of observers[10] was 0·52, confirming considerable agreement.

The median age at death in the series was 42 years (range 7 weeks-94 years) identical with the median age of the preventable deaths (41 years, range 3-85 years).

In 58 (34%) of the deaths considered to be preventable death occurred within four hours of reaching hospital against only 79 (23%) of the 344 deaths judged not preventable. In a further 52 patients (23%) death occurred between one day and one week in hospital (fig 3).

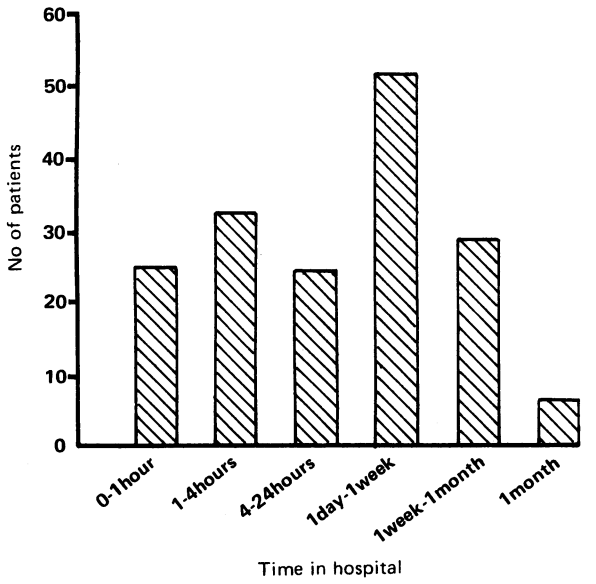

FIG 3—Interval from admission to hospital until death in cases of preventable death.

One hundred and five patients (62%) whose deaths were preventable had injuries that would normally be treated by operation: 83 (79%) had no operation, or a delayed operation, or incomplete surgery. In 63 (56%) of the deaths not associated with the central nervous system haemorrhage was a major cause of death. Of these patients, only one appeared to have undergone an adequate surgical procedure, while 29 died without operation. There were six deaths from haemorrhage during or after transfer to another hospital for treatment of a head injury, five being due to a ruptured spleen or liver.

Acute hypoxia appeared to be a factor in 22 of the 170 preventable deaths. Fifteen of these were the result of aspiration, 12 being in patients with a concomitant head injury. In 86 of the 170 deaths an important injury was not diagnosed. Treatment would probably have saved 79 (92%) of these cases. The commonest missed diagnoses were ruptured liver (22 patients), lacerated lung (18), ruptured spleen (12), and subdural haematoma (12) (table III).

TABLE III—*Commonest missed diagnoses*

Head and neck:	*Abdomen:*
12 subdural haematoma	22 ruptured liver
2 extradural haematoma	12 ruptured spleen
3 lacerated neck vessel	7 ruptured mesentery
2 cervical spine fracture	5 ruptured kidney (3 parenchymal, 2 vascular)
	3 ruptured pancreas
Thorax:	3 perforated small bowel
18 lung lacerations (14 parenchymal, 4 hilar)	3 perforated bladder
6 haemothorax	3 perforated ulcer
3 pneumothorax	2 ruptured diaphragm
2 lacerated subclavian artery	2 lacerated iliac vessels

Interestingly, pulmonary embolism remains an important cause of death, being present in 37 of the 514 hospital deaths, and was the main cause of 20 of the 170 preventable deaths (12%). Patients in this group, although older on average than the others (mean age 62, range 18-86 years) were less severely injured and had a mean Injury Severity Score of 10.

Finally, 69 of the preventable deaths were treated in teaching hospitals and 101 in non-teaching hospitals. Although there were minor differences in management and outcome between the two types of hospital neither appeared to manage the severely injured patients adequately (table IV).

TABLE IV—*Analysis of preventable deaths by hospital of presentation*

	Teaching hospital	Non-teaching hospital
No of preventable deaths	69	101
No (%) unrelated to central nervous system	49 (71)	64 (63)
No (%) central nervous system	20 (29)	37 (37)
Mean age (years)	44	40
Mean Injury Severity Score	29	28
No (%) needing surgery	41 (59)	64 (63)
No (%) of cases needing surgery having delayed, inadequate, or no surgery	30 (73)	53 (83)
No (%) missed diagnosis	27 (39)	59 (58)
No (%) multiply injured dying within six hours and without indicated surgery	13 (37)	24 (44)

Discussion

The evolution of accident and emergency services in the UK was described in the *BMJ* in 1981.[11] At that time the studies in the USA that were evaluating trauma care were well advanced. More than 20 studies concentrating on treatment in hospital have been carried out and have been reviewed by Cales and Trunkey[12] and Kreis *et al.*[13] Most showed similar results and led to the same conclusion—namely, that for optimal results the management of severely injured patients should be carried out in trauma centres. The findings in the present study suggest that in the UK we too have deficiencies in the management of major trauma similar to those described in the USA.

Although our study has all the defects inherent in a retrospective trial, the design and results are similar to those in trials undertaken in the USA. The method of evaluating the care of the injured by necropsy findings has been described and validated and is, if anything, conservative in its findings.[14,15] Nevertheless, caution must be exercised in interpreting the findings. Thus although we have classified up to 170 deaths as being "preventable," even in the best hands a proportion of these would have died. In particular those who died from thromboembolism and some of the older patients with intracranial complications might still have died although being treated promptly and skilfully. Similarly, some of the hepatic and intrathoracic injuries, although theoretically salvageable, may have proved to be technically too demanding.

The different patterns of injury between the UK and the USA, particularly the incidence of penetrating injuries, is important, but it is notable that two thirds of the similar trials reviewed by Cales and Trunkey dealt solely with motor vehicle accidents,[12] thus giving a pattern of injury more analogous to our own. Previous workers largely have used consensus views on preventability, rather than the independent assessment used—probably to advantage—in this study.

Kreis *et al*, quoting the results of 17 other trials using methods similar to ours, showed a mean preventable death rate of 19·3%.[13] While this is identical with our four of four agreement on preventability death rate, their methods of analysis make their figures comparable with our rate of 33% for preventable deaths when three in four agreement was incorporated. Trunkey believes that some 30% of deaths in hospital after injury are preventable when there are no specialised trauma services.[16]

In line with other studies the highest preventability rate in our study is in hospital deaths not associated with the central nervous system. Out of 514 admissions, there were 179 of these deaths of which 113 (63%) were judged to be preventable. West *et al* found a rate of 73% for such deaths in suburban California in 1974,[3] while Cales reported 86% in 1978.[6] Of the preventable deaths unrelated to the central nervous system in our series, haemorrhage was a contributory factor in just over half, while 67 of 113 cases (59%) died without necessary surgical operations. West *et al* considered that 57% of the preventable deaths resulted from haemorrhage,[3] while

Kreis *et al* in Florida considered that lack of or delay in performing an appropriate surgical procedure accounted for 82·7% of the preventable deaths.[13]

The mean Injury Severity Score of preventable deaths not related to the central nervous system in our study was 29, which compares poorly with other studies. This may partly be attributable to differences in calculation of the score or the exclusion of patients dying of a remote cause. Removal of remote causes from our figures results in a mean Injury Severity Score of 35 for injuries not of the central nervous system. This is still below the 42 reported in an American study[13] before trauma centres were established, but equates with the 32 reported by Dove *et al* in New York.[17] Scales derived by Bull show that half of the patients under age 45 with an Injury Severity Score of 40 can be expected to die.[18]

The results of treating severe injuries presented in this paper are at least as poor as those which stimulated a prompt evaluation and reorganisation of major trauma services in the USA. If our figures are extrapolated to a national scale each year some 2500 injured people reaching hospital will subsequently die from a potentially recoverable condition. When teaching and non-teaching hospitals are compared neither appears to be treating major injuries adequately. More detailed assessment of the figures gives some indication of where the problems lie. Although in this study deaths before arrival at hospital were not examined, it is obvious from the variation in rates of those dead on arrival that prehospital care leaves much to be desired in some districts, especially where the rate exceeds 50%.

Of the 170 patients whose deaths were judged preventable, 89 (52%) had multiple injuries. Of these, 73 (82%) apparently needed an operation, but 57 (78%) did not receive one. The standard that can be reached in a trauma centre was described by Fischer *et al*, who reported that 74% of patients in need of laparotomy had the operation within 30 minutes of admission.[19] Studies in the USA, where trauma centres have gained progressively wider acceptance, have often shown remarkable improvements in survival. Thus despite dealing with an older and more severely injured population the centralised San Francisco trauma centre had only one of 16 preventable deaths unrelated to the central nervous system as opposed to 22 of 30 such deaths in nearby Orange County with its many emergency departments.[3] After a trauma centre was set up Orange County showed a fall from 73% to 9% in the rate of such preventable deaths unrelated to the central nervous system. At the same time cases dealt with in other hospitals continued at a rate of 67%.[5] Much of the improvement was attributed to aggressive resuscitation and prompt operation. The proportion of patients receiving an appropriate operation increased from 20% to 89%, almost matching the 94% of the long established San Francisco trauma centre. The ordinary emergency departments had no change in their rates for appropriate operations and continued with a high (50%) death rate from haemorrhage.

The fear that longer transport times to trauma centres will increase the prehospital death rate has not been borne out.[20] Shackford *et al* reported a reduction in delay in treatment from 41·3% of cases to 10·6% after a trauma centre was established.[4] While in the USA trauma centres have obviously been successful in improving the prognosis of severely injured patients, they have not gained universal acceptance and alternative systems are worth considering. It may be argued that similar benefits can be obtained from training selected surgeons with special skills to manage the injured who could work alongside consultants in accident and emergency medicine to provide immediate services for severely injured patients.

Preventable deaths after injury occur primarily because of missed diagnosis; failure to control haemorrhage or hypoxia, and inadequate, delayed, or non-existent surgical intervention. All the principal workers in this specialty—Trunkey,[20] West *et al*,[3] Shackford *et al*,[4] Kreis *et al*,[13] in the USA and Hoffman[21] and Gilroy[22] in the UK—have reached the same conclusions. We must now do more for severely injured patients.

We thank the coroners in the anonymous districts that we studied for their willing collaboration in allowing us access to their records. Similarly, we thank our assessors for their hard work in assessing the 1000 trauma deaths.

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CLINICAL CURIO

Spontaneous formation of a second urinary bladder

A farmer from Zaire, probably in his sixties, came to our rural hospital with a history of lower urinary tract obstruction. He had had his first operation 32 years earlier and many since, the most recent being a urethroplasty at the most advanced hospital of the area in 1985. After that he had passed urine well enough to neglect his follow up appointments.

Three months before coming to our hospital micturition became increasingly difficult until urine came in drops only and gradually a swelling appeared in the left scrotum. For the last month the patient could not empty his bladder, but urine was produced in reasonable amounts by squeezing the scrotal swelling, which would then slowly fill up again. He did this four or five times a day. In fact he had chronic retention with a bladder up to the umbilicus and a continuous slow overflow into a scrotal cavity which functioned as a second bladder and could be emptied manually. In this way continence was maintained.

When we attempted to dilate the urethra an impassable perineal stricture proximal to the old urethroplasty was found. Bougies could be passed easily into the scrotal "bladder" but not further. Since the urine was heavily infected the scrotum was drained externally and a suprapubic cystostomy constructed to divert the urinary stream. One week later I did an external urethrotomy as advised by Griffith.[1] I found a stricture 1 cm long with a passage into the scrotal cavity immediately distal to it. When the stricture was incised longitudinally a Foley's catheter could be passed along the full length of the urethra into the bladder. Periurethral tissues and skin were closed over this. Two weeks later the patient mysteriously lost his catheter and passed urine normally. The scrotal cavity had virtually disappeared. We advised the man to keep his appointments for regular urethral dilatation, but he left the hospital and was not seen again.—CHRISTINA M DE WIND, Médecin Chef de la Zone de Santé Rurale de Boga, Zaire.

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