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EPIDEMIOLOGY IN ANAESTHESIA
I: ANAESTHETIC PRACTICE OVER 20 YEARS

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SUMMARY

The practice of anaesthesia and its outcome is compared, by means of the Cardiff Anaesthetic Record System, between two periods of 6 years, in which 53 541 and 108 878 anaesthetics were administered by the staff of one department. The proportion of emergency cases has increased from 10.6% to 18.7%, but the mortality in hospital has declined from 1 in 35 anaesthetics to 1 in 46

Three previous accounts (Mushin et al., 1954; Mushin, Campbell and Ng, 1967; Lunn, 1976) have outlined the development since 1949 of the anaesthetic record system in Cardiff and have provided year-by-year comparisons. The main purpose of the present report is to describe the system which was in use between 1972 and 1977 and the data which were accumulated during that period. This comprises information about 108 878 anaesthetics. An opportunity was also taken to make comparisons with an earlier series of 53 541 anaesthetics acquired over a similar 6-year period from 1958 to 1963. Subsequent papers describe and explore the relationship between hospital mortality and preoperative condition, duration of anaesthesia, and cardiac arrest during operation.

THE SYSTEM

Until 1972, the system was based on manual or machine sorting of Hollerith punch cards. From 1972 onwards the data have been stored on the ICL system 4-70 at University College, Cardiff. Data from the earlier period have been transferred recently to the same system.

Each time an anaesthetic is given to an inpatient, an anaesthetic sheet is completed by the patient's anaesthetist. This sheet is the only record of that patient's anaesthetic and is used as the source of data for both the computer system and the patient's clinical record. Therefore all patients having an anaesthetic are recorded by the system.

The record includes a large amount of descriptive information about the patient's condition before surgery, a record of events during the anaesthetic, including an arterial pressure chart, the events during the period of immediate recovery and the frequency of complications after surgery. The card is not self-coding and the next day the anaesthetic record clerk (of which there are three in different hospitals) transfers those items indicated by the anaesthetist by number to a series of boxes.

The anaesthetic record is allocated an individual number. The record is then returned to the anaesthetist for completion and the inclusion of postoperative complications. When this has been done the record clerk checks the sheet again, inserts numbers for the duration of hospital stay or the occurrence of death and sends it to the computer unit. The data for up to 160 boxes per patient are punched onto cards and then entered into the computer.

There is, in addition to the anaesthetic record card to which we have referred, a summary sheet which the anaesthetist completes at the time of the anaesthetic. This is retained in each patient's hospital clinical record and is available for any subsequent admission to hospital.

Validation

When the data are entered into the computer a validity check is performed so that gross errors (for example, male operations upon female patients) are eliminated. Errors are listed and the anaesthetic record clerk notified, so that these sheets may be corrected and subsequently re-entered into the computer; at this stage the master file is created.

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The second part of the validation of the data for 1972–77 analysed in this paper is not carried out routinely, but when this current study was planned a unique opportunity arose, through the Job Creation Programme, to check the accuracy of the system. Five thousand random anaesthetic records were listed by number and the content of each was checked with the relevant information in the patient's hospital notes. The comparison was confined to a number of readily verifiable items of information on the summary anaesthetic sheet or the patient's documents (for example, premedication, diagnosis, use of certain drugs, duration of stay after operation, and the occurrence of death). The record clerks were shown by this process to be responsible for an error rate of 0.75%, the punch operators for 0.2% and the anaesthetists 5%.

RESULTS

Age and sex of the patient populations

Table I shows the percentage of females and males by age in both series. The two series show very little change in relation to age and sex structure. Compared with women, a higher percentage of males having anaesthetics are operated on in the youngest age range (0–14 yr), and in the older ranges 55 yr and over; women show a higher percentage than males in the 15–54 yr ranges. The overall female to male ratio was 1.4 :1 in the earlier series and 1.3 :1 in the later.

TABLE I *Percentage age distribution of males and females having anaesthetics*

Age (yr)	1958–1963		1972–1977	
	Male(%)	Female(%)	Male(%)	Female(%)
0–14	17.1	6 6	17.1	7.4
15–24	10 2	12.0	12.1	15.7
25–34	9.7	15.4	10.3	20 4
35–44	10 6	17 1	9 8	15 9
45–54	12.1	16.4	13 5	15.0
55–64	14 8	13 3	16.6	10 8
65–74	12.7	10.3	14 2	8.9
75–84	7.5	5 8	5.7	4 7
85+	2.3	1 9	0 8	1 1
Not known	2.8	1 0	—	—
All ages	100	100	100	100

Sites of operation

The number of operations increased from 53 541 to 108 878, principally as a result of the increase in the provision of surgical services with the opening of the University Hospital of Wales in 1972. The range of operative sites which are coded has broadened since the earlier series; the common sites are listed in table II. The changes include the separation of cystoscopy and radiological procedures from other sites. It should be noted, in addition, that much of the elective orthopaedic surgery in this Area is performed in a hospital which is not included in the record system and that in 1958–63 almost all the thoracic (pulmonary and cardiac) surgery was also outside the system.

TABLE II *Percentage of principal operations performed at various sites*

Operation site	1958–1963	1972–1977
Perineal	26.1	21 9
Lower abdomen	17 7	15.9
Upper abdomen	9 7	7 0
Leg	6.7	8.0
Nose and throat	5 4	3 6
Inguinal	5 0	4 1
Intracranial	1 7	1.1
Obstetrics	1 8	1 9
Cystoscopy	—	7 6

Clinical assessment before operation

Anaesthetists were able to indicate their overall clinical assessment of the patient's general condition before surgery in a similar manner to that of the Americal Society of Anesthesiologists classification (Dripps, Lamont and Eckenhoff, 1961). Table III shows how the surgical population has changed. There was a substantial increase in the 1972–77 series in the proportion of patients with major impairment, and of those who were in a bad or a moribund condition. This may be partly accounted for by the fact that the proportion of emergencies increased from 10.6% to 18.7% between the two series, or could possibly be a result of a change in the subjective impressions of anaesthetists.

TABLE III *Relative distribution (%) of preoperative clinical assessments*

Clinical assessment	1958–1963 (n = 53 541 = 100%)	1972–1977 (n = 108 878 = 100%)
Good	43 5	47 4
Minor impairment	48 3	31 0
Major impairment	7.2	18 9
Bad	0 8	2 3
Moribund	0 09	0 3

Anaesthesia

The practice of *premedication* has changed markedly (table IV). Whereas in the early series almost all anaesthetics included a premedication with atropine or hyoscine, in the later group this happened in only 75% of anaesthetics. This may partly be on account of the decline in the use of diethyl ether, but also because of the increasing awareness of the unpleasant subjective effects of these two drugs.

There has been a 30% reduction in the use of morphine in premedication and a substantial increase in the use of other drugs—mainly the sedatives and anxiolytics such as the butyrophenone and benzodiazepine drugs.

In the early series it is impossible now to determine much about the use of *i.v. agents*, although 89.6% of anaesthetics included thiopentone or other barbiturate. In the later series, however, 82% of patients received thiopentone. The advent during this time of Althesin (used in 7.3% of anaesthetics) seems hardly to have affected the predominant position of thiopentone.

Anaesthetists seem to be using fewer *inhaled agents* (except for nitrous oxide) in the recent series than used to be their practice (table V). Halothane and particularly trichloroethylene are used much less frequently. (It should be noted that the use of one agent only in addition to nitrous oxide could be recorded for each anaesthetic in the 1958–62 series and anaesthetists recorded the main agent. There was no such limit in the later series.)

The overall use of *muscle relaxants* has declined only slightly from 68.9% to 65.4% of all anaesthetics administered. Table VI shows how the use of individual non-depolarizing relaxants and reversal agents has altered following the introduction of pancuronium. Compared with gallamine and tubocurarine, pancuronium is associated with a statistically significant increase in the use of postoperative ventilation in the recovery room (table VII).

Table VIII applies to the more recent series only; it is not possible to be certain of the frequency of combined or single use of relaxants in the early series. We do know, however, that 42.3% of patients who received relaxants received suxamethonium (or suxethonium, now withdrawn) in the early series, whereas 9.8% had suxamethonium in the recent series.

The *analgesics* fentanyl and phenoperidine were introduced into clinical practice during this time (1972–77) and table IX shows that their use during

TABLE IV *Use of premedicant drugs—percentage of anaesthetics*

	1958–1963 (%)	1972–1977 (%)
Antisialagogue		
Atropine	64 3	41 5
Hyoscine	35 0	33 2
No antisialagogue	0 8	25 1
Analgesic/sedative		
Morphine	41 1	11 7
Papaveretum	33 6	36 7
Pethidine	9 0	10 9
None	15 2	21 4
Others	1 1	19 3

TABLE V *Use of specific inhalation agents—percentage of anaesthetics*

Agent	1958–1963 (%)	1972–1977 (%)
Nitrous oxide	94.3	91 2
Halothane	72.3	64 1
Trichloroethylene	21 3	7 1
Cyclopropane	1 6	0.4
Diethyl ether	5 0	0 6
Others	3.9	0 3

TABLE VI *Relative use of certain non-depolarizing relaxants*

	1958–1963 (%)	1972–1977 (%)
Non-depolarizing relaxant	(n = 21 730)	(n = 45 961)
Gallamine	73 2	7.9
Tubocurarine	26 8	10 6
Pancuronium	—	78 9
Other	—	2 5
Total non-depolarizing relaxants	100	100
Total reversal agents (% recipients of relaxants)	62 3	87 6

TABLE VII. *Requirement for postoperative ventilation after pancuronium, tubocurarine or gallamine* $*\chi^2 = 4.17$; $df = 1; P < 0.05$. $**\chi^2 = 10.56$; $d.f. = 1, P < 0.005$

After use of	Ventilation	No ventilation
Pancuronium	234	36047
Tubocurarine	19	4856*
Gallamine	7	3635**

TABLE VIII *Relative use of muscle relaxants in 1972–1977*

	Percentage of all relaxants ($n = 71\,234$)
Suxamethonium alone	35.8
and tubocurarine	4 5
and gallamine	3 1
and pancuronium	35 7
and other	0 7
Tubocurarine alone	2 3
Gallamine alone	2.0
Pancuronium alone	15.0
Other	0 8
Any single or combined relaxant	100

TABLE IX *Choice of analgesic by grade of anaesthetist—numbers of anaesthetics*

Anaesthetist	Fentanyl	Phenoperidine	Morphine	Pethidine
Consultant	4320	860	1218	859
Senior registrar	3929	1170	769	190
Registrar	7881	820	1459	745
Senior House Officer	2233	151	190	270
Medical/ Clinical assistants	182	134	21	55

anaesthesia is much more common than that of morphine and pethidine. However, this is associated with the grade of anaesthetist and the trainees more commonly use these drugs than do the consultants ($\chi^2 = 2621$; d.f. $= 12$; $P < 0.00001$).

Spinal and extradural anaesthesia

In 1958–63 0.3% of anaesthetics were spinal or extradural, compared with 2.3% in 1972–77. The early period was in the aftermath of the medico–legal case of Wooley and Roe and shows the effect which that case may have had on anaesthetic practice.

I.v. fluids and monitoring

The use of i.v. fluids has apparently increased from 11.3% to 36.1% of anaesthetics, although that of blood transfusion does not seem to have changed—9.4 and 10.6% respectively in the two series.

The arterial pressure was measured indirectly during anaesthesia in the 1972–77 series in 82% of anaesthetics and the electrocardiograph was used in 53%. Monitoring *instruments* were not used in 10% and ventilation was measured in 30% of anaesthetics.

Incidents during anaesthesia

An incident is defined as an occurrence of sufficient importance to necessitate a change in the management of the anaesthetic; such incidents occurred in 45% of anaesthetics in the early series and in 19.8% of the later series.

Duration of anaesthesia

Figure 1 shows the cumulative percentage of duration of anaesthesia. In both series, approximately two-thirds were completed by 1 h and only 3% took longer than 3 h.

Postoperative hospital stay

Table X confirms other data that the postoperative hospital stay of surgical patients has declined. In particular, whereas 16.7% of patients stayed in hospital less than 4 days after operation in 1958, in 1977 40.7% were discharged in less than 4 days. This was a result of changes not only in anaesthetic practice but also in surgical and other practices.

TABLE X *Postoperative stay in hospital (cumulative %)*

Days	1958–1963	1972–1977
0–3	16.7	40 7
4–6	38 8	58 1
7–13	68 5	84 1
14+	83.5	92 2

Death following surgery

The overall death rate (irrespective of its timing or its cause) in hospital has declined from 2.86 to 2.19 per 100 anaesthetics. This figure may reflect changes in anaesthetic practice as well as the surgical management of patients. Other papers in this series will deal with this matter in detail. Table XI shows the percentage distribution of the day of postoperative death: almost two-thirds had occurred within 2 weeks of operation.

In the 1958 series 31.2% of the deaths had occurred within the first 3 days compared with 26.0% on the later series ($\chi^2 = 12.99$; d.f. $= 1$; $P < 0.0005$).

Preoperative conditions (1972–1977)

From a total of 107 individual preoperative condi-

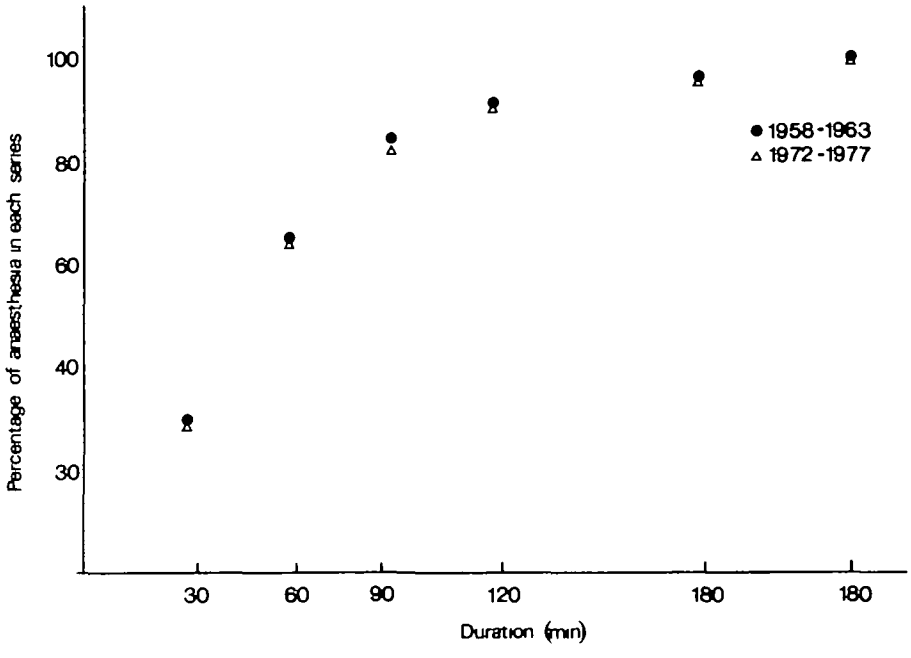

FIG 1. Cumulative percentage of anaesthetics by duration of operation

TABLE XI *Day of postoperative death. Percentage of patients dying at each time*

Day	1958–1963 ($n = 1532$)	1972–1977 ($n = 2391$)
Theatre	2.1	4 3
Recovery room	—	1.1
0	7.6	4.2
1–3	21.5	16.4
4–6	13.4	17.1
7–13	20 3	20.0
14–20	10.7	15.2
21+	24.1	21.6

TABLE XII. *Frequency of preoperative conditions*

	% Anaesthetics
Chronic lower respiratory tract infection	7.4
Emphysema, pneumoconiosis or pulmonary fibrotic lesion	2.1
Angina	1.9
Ischaemic heart disease	3 9
Pregnant (but non-obstetric operation)	0.3
Renal failure (acute and chronic)	0.6
Excessive alcohol intake	1.4
Obesity	5.0
Weight loss	1 8
Diabetes (controlled and uncontrolled)	1.3
Impairment of health by surgical diagnosis	9.8
Allergies	2.5
Relevant deformities	0.9
Previous untoward incidents during anaesthesia	0.25

tions, the anaesthetist could select up to 10 different items to be recorded. On the average, just over two were recorded per anaesthetic. Some of the common ones are listed in table XII, but it is clear that they are not all of equal import.

In table XIII, all the preoperative conditions have been grouped together by system. Some of the groups have an unexpectedly high frequency. In particular, the "central nervous system" group included an item "marked apprehension" and this accounts for 48% of the occasions when this system was indicated. The "iatrogenic" group included an indication of previous anaesthetic and the "other" group included "impairment of general health" which accounted for 56% of the occasions on which the system was indicated.

TABLE XIII. *Frequency of preoperative conditions by system (1972–1977). (More than one condition could be recorded) *48% apprehension; **56% impairment of general health by surgical diagnosis*

	% Anaesthetics
Respiratory	20.5
Cardiovascular	
symptoms/signs	9.2
diagnosis	13.7
Gynaecological/obstetric	2.0
Central nervous*	16.3
Urinary	2.5
Alimentary	5 2
Metabolic and endocrine	
signs	11.5
diagnoses	2.9
Iatrogenic	30 9
Other**	17 3

Previous general anaesthetic

In the later series it was possible to record the occurrence of previous general anaesthetics. In 2.7% of cases it was recorded that there had been an anaesthetic given to the same patient in the period less than 4 weeks before the present anaesthetic; 3.4% of patients had had an anaesthetic up to 6 months before and 7.3% of patients had had an anaesthetic between 6 months and 5 years before. Thus, in this particular population the problem of repeated anaesthetics does not seem to be a common one.

DISCUSSION

Analysis of information from records of anaesthesia has seldom been attempted in the United Kingdom on this scale before and we are convinced that, whilst much of the information contained in this report may be appreciated on an individual basis and even be commonplace, nevertheless there is a need for it to be documented. Furthermore, if there are conclusions to be drawn they may be made with some confidence because of the large numbers reported and because of the low error rate. The fact that anaesthetists are no different from other doctors in relation to accurate record keeping need not be the occasion for surprise, merely for disappointment.

It is clear that the record and computer systems used here are powerful tools for epidemiological research and capable of many applications. In particular, this system has already been used as a springboard for clinical research (Rosen and Mushin, 1967) and could easily be utilized for clinical audit. However, it is expensive and time-consuming for anaesthetists and clerical staff. The record has therefore been revised to reduce the time necessary for its completion: the rationale of this is described elsewhere (Lunn and Vickers, 1982).

The change in surgical practice which has followed advances in medicine and pharmacology is exemplified by the increased admission of seriously ill patients for surgery. Despite this fact the hospital mortality has decreased to 1 in 46 anaesthetics. Specialist hospitals are likely to have a greater proportion of these ill patients than district general hospitals. The increased number of emergency operations may reflect pressure for operating time during the day which is relieved by the designation, wrongly in our view, of an operation as an emergency which is then performed when perhaps neither facilities nor skilled staff are easily available.

We are disappointed to note that the records state that no monitoring instruments were used at all in 10% of anaesthetics and that i.v. fluids were not given more frequently. It is easy to omit routine information from the record and this may be the explanation but, if so, it only emphasizes the necessity to ensure that any record is as complete as possible before conclusions about practice are drawn.

The association between the use of pancuronium and the necessity for postoperative ventilation of the lungs in the recovery period is interesting. The same unpublished observation was made in the early period of use of the drug on the basis of the anaesthetic records for 1 year and this study confirms the preliminary observation. Pancuronium may have been used preferentially at the time of these anaesthetics for poor-risk or emergency cases because it was recently introduced and was then believed to be free of cardiovascular effects. Prophylactic postoperative ventilation and the use of potent narcotics had also become popular in the interim and facilities for intensive care more available. We do not suggest that there is a causal relationship between these two events, but the observation may serve to alert clinicians that such a possibility exists.

It is not surprising that trainees tend to use drugs which have been recently introduced but the evidence of patient benefit seems to be less obvious to their trainers! This may be a matter of considerably wider interest than that of anaesthetists and could be investigated in other areas of medical practice.

Readers may be surprised that we have made no comment about complications after operation. This important matter, we have found over the years, is not studied satisfactorily through the anaesthetic record system. There are a number of reasons for this—the multifactorial nature of their causation, in particular their temporal relationship to the anaesthetic and the anaesthetist's postoperative visits, all of which combine to preclude accurate recording. In these studies we have therefore concentrated on postoperative information which we have reason to believe is well recorded, namely postoperative stay and death, which are noted by the clerical staff employed in the system.

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EPIDEMIOLOGIE EN ANESTHESIE I. PRATIQUE DE L'ANESTHESIE SUR PLUS DE 20 ANS

RESUME

La pratique de l'anesthésie et ses résultats sont comparées grâce au système de fichier anesthésique de Cardiff au cours de deux périodes de 6 ans pendant lesquelles 53 541 et 108 878 anesthésies ont été délivrées par l'équipe d'un même département. La proportion des urgences a augmenté de 10,6% à 18,7% mais la mortalité à l'hôpital a diminué de 1 pour 35 anesthésies à 1 pour 46

EPIDEMIOLOGIE IN DER ANÄSTHESIE I: ANÄSTHESIOLOGISCHE PRAXIS WÄHREND 20 JAHREN

ZUSAMMENFASSUNG

Anastheaiologische Erfahrungen und ihre Ergebnisse werden mit Hilfe des "Cardiff Anaesthetic Record Systems" zwischen zwei Perioden von 6 Jahren verglichen, in denen 53 541 und 108 878 Narkosen durch den Staff einer Abteilung durchgeführt wurden. Der Anteil der Notfälle nahm von 10,6% auf 18,7% zu, wahrend die Todesfalle im Krankenhaus von 1 auf 35 Narkosen zu 1 auf 46 Narkosen abnahmen.

LA EPIDEMOLOGIA EN LA ANESTESIA I–LA PRACTICA ANESTESICA DURANTE 20 AÑOS

SUMARIO

Se utiliza el Sistema de Registros Anestésicos de Cardiff para la comparación de dos periodos de 6 años, relativos a la anestesia y a su resultados, durante los que se administraton 53.541 y 108.878 anestesias por parte del personal de un departamento. La proporción de casos de urgencia ha aumentado desde el 10,6% hasta el 18,7%, pero el índice de mortalidad en el hospital ha declinado desde 1 por cada 35 anestesias hasta 1 por cada 46