

Perioperative Deaths: A Further Comparative Review of Coroner's Autopsies with Particular Reference to the Occurrence of Fatal Iatrogenic Injury

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Abstract

Introduction: In previous triennial reviews of Coroner's perioperative autopsies conducted during the periods 1989 to 1991 and 1992 to 1994, it was observed that the necropsy incidence of such deaths rose from 2% to 2.6% ($P < 0.05$). Concurrently, the rate of iatrogenic deaths had nearly doubled from 15.2% to 28.8% ($P < 0.02$). These findings spurred a review of the subsequent triennium (1995 to 1997), in order to monitor the apparent rise in these trends and to study the frequency and occurrence of iatrogenic deaths in relation to the number of invasive procedures performed, as well as during emergency and elective procedures. **Materials and Methods:** A retrospective (descriptive and comparative) study, comprising a clinico-pathological review of a series of 270 perioperative deaths (defined as deaths occurring during or after invasive therapeutic or diagnostic procedures, up to a week after discharge, and excluding cases of major trauma from suicides, homicides, as well as road and industrial accidents) reported to the Coroner, for which autopsies were conducted at the Department of Forensic Medicine from 1995 to 1997. **Results:** The necropsy incidence of 4.4% (270/6074) represented a significant rise over the previous triennia ($P < 0.01$). As in previous years, there was a predominance of males (M:F = 1.65:1) and middle-aged to elderly patients (range 0 to 92 years, mean 55.8 years, median 63 years), most of whom had died after a variable, but usually brief, postoperative interval [0 to 97, 4.2, 1 day(s)] and a more variable period of hospitalisation (<1 to 289, 12.6, 7 days). A total of 408 invasive procedures were performed, amounting to an average of 1.5 per patient; 101 patients (37.4%) underwent multiple (>1) interventions, which were initially classified as elective procedures in 27 cases. There were 66 (24.4%) iatrogenic deaths, of which 2 (0.7%) were due to anaesthetic mishaps; 18/64 iatrogenic deaths, unrelated to anaesthesia, occurred after the first postoperative day. The proportions of such deaths amongst patients subjected to multiple interventions, or initial elective procedures, were more than twice as high as amongst those undergoing single procedures, and those initially classified as emergencies (35.6% versus 16.6% and 33.3% versus 13.2%, respectively; $P < 0.01$). Only 51/66 (77.3%) iatrogenic deaths received Coroner's verdicts of misadventure; no verdict of criminal negligence was recorded during the period in question. **Conclusions:** There appears to have been a steady increase in the number of perioperative deaths reported to the Coroner over the previous triennia (1989 to 1997) for which autopsies were conducted. While this observation may not denote an increase in perioperative mortality rates per se, it may be indicative of an increasingly "aggressive" or defensive approach to the clinical management of seriously ill patients, particularly over the past decade. Although the rate of iatrogenic deaths appears to have stabilised, it is too early to say whether this apparent trend will persist in the future. It is perhaps not surprising that the risk of iatrogenic injury appears to increase with the number of interventions performed; however, it is not clear why initial, supposedly elective, interventions should be associated with an apparently greater risk of iatrogenic injury than those classified as emergency procedures. The substantial divergence between the autopsy finding of an iatrogenic death and the corresponding Coroner's verdict of misadventure may be comforting to clinicians, but certainly warrants further examination.

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Introduction

Beginning in 1991, the Department of Forensic Medicine (DFM), which undertakes all Coroner's casework locally, embarked on an on-going review of Coroner's perioperative autopsies on a triennial basis. The aim is to document significant clinico-pathological and medico-legal trends arising from perioperative deaths in anticipation of the increasing importance of medical audit to medical practice.

Earlier endeavours revealed a significant increase in the incidence of both perioperative autopsies (from 2% to

2.6%, $P < 0.05$) and a doubling of the rate of iatrogenic deaths arising therefrom (from 15.2% to 28.8%, $P < 0.02$) during the second triennium (1992 to 1994) over the preceding one (1989 to 1991).^{1,2}

These findings spurred a review of the subsequent triennium (1995 to 1997), with the principal objectives of monitoring the apparent rise in these trends and, more specifically, assessing the possibility of a relationship between the number of invasive procedures performed and the occurrence of iatrogenic deaths, as well as the

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frequency of such deaths during emergency and elective procedures.

Materials and Methods

For the purpose of this study, a perioperative death was defined as one occurring during or after an invasive therapeutic or diagnostic procedure, up to a week after discharge. Cases of major trauma from suicides, homicides, as well as road and industrial accidents were excluded, as these are being assessed by means of major trauma outcome studies, undertaken in collaboration with certain clinical departments.

Employing a methodology similar to, but more expansive than that used in the previous studies,^{1,2} a retrospective review of the relevant Coroner's post-mortem reports was undertaken. This was performed in conjunction with a review of the corresponding clinical records, in order to determine the profile of the subjects; the temporal relationship between death and the preceding invasive procedure(s), in each case; the total number of procedures performed on each patient during the last admission; the relative frequencies of iatrogenic deaths amongst patients who underwent single, as opposed to multiple (>1) interventions, as well as initial procedures classified by the principal operators as being either emergencies or elective in nature. The degree of convergence between the nature of all deaths, as determined by autopsy, and the corresponding Coroner's verdicts was also determined.

These deaths were then classified according to the following schema (adapted from Knight^{3,4}):

Category	Definition
1	Death due to the disease or condition for which the operation was performed
2	Death due to a disease or abnormality other than that for which the operation was performed
3	Death arising from a surgical complication or mishap
4	Death arising from an anaesthetic complication or mishap
5	Death associated with, or attributable to the patient's behaviour
6	Uncertain mode of death

Where appropriate, the results of the period under study were compared with those of the previous triennia; differences in proportions were assessed by means of the χ^2 test (with Yates and Bonferroni corrections, as indicated). A *P* value less than 0.05 was considered to be statistically significant.

Finally, a series of anonymised vignettes, extracted from notable iatrogenic deaths of actual or potential medico-legal significance, was also collated and appended.

Results

Incidence and Trend

There was a total of 6074 Coroner's autopsies between 1995 and 1997, of which 270 (4.4%) were conducted in cases of perioperative deaths, as defined for the purpose of this study. This was a statistically significant (*P* < 0.01) relative increase in the perioperative necropsy incidence of some 69% over the previous triennium, and appears to reflect a rising trend in the reporting of such deaths that may be sustained against a progressive decline in the total number of Coroner's autopsies conducted during the corresponding periods. Indeed, the increasing trend throughout all 3 triennia was statistically significant (*P* < 0.001) (Table I).

As in the past, there was a preponderance of males, the male to female ratio of 1.65:1 being identical to that of the previous triennium and not significantly higher than that observed in the first (1.36:1). Similarly, the age distribution had largely been preserved over the same time (Fig. 1), with a peak age incidence in the seventh decade and over half of the subjects being aged 60 years or older; the corresponding rates for the period 1995 to 1997 being 22.6% and 55.6%, respectively (mean 55.8, SD $\pm$ 23.4 years). Accordingly, the triennial age range, as well as the mean and median ages have also remained stable (1989 to 1991: 0 to 96, 59, 51.0 years; 1992 to 1994: 0 to 93, 64, 55.3 years; 1995 to 1997: 0 to 92, 63, 55.8 years).

Duration of Hospitalisation

The vast majority (251, 93%) of patients spent 30 days or less in hospital. Although the range was considerably wider than in the previous triennium (<1 to 289 versus <1 to 183 days), the median and mean duration of hospitalisation (7, 12.6, SD $\pm$ 23.4 days) remained much the same (6, 11.5, SD $\pm$ 17.0 days). There were only 2 cases of death occurring within a week of discharge during the current triennium.

Postoperative Interval

Again, an overwhelming majority of patients (267, 98.9%) died within 30 days of an operation or procedure. Notably, the median postoperative interval was 1 day (mean 4.2, SD $\pm$ 9.1 days), this being identical to that over the previous

TABLE I: TRIENNIAL DISTRIBUTION OF CORONER'S CASES AND PERIOPERATIVE DEATHS (1989 TO 1997)

Period	1989-1991 ¹	1992-1994 ²	1995-1997 ³
Cases	132	170	270
Coroner's autopsies	6605	6468	6074
Incidence (%)	2.0	2.6	4.4

χ^2 for trend = 65.29; 3df (*P* < 0.001)

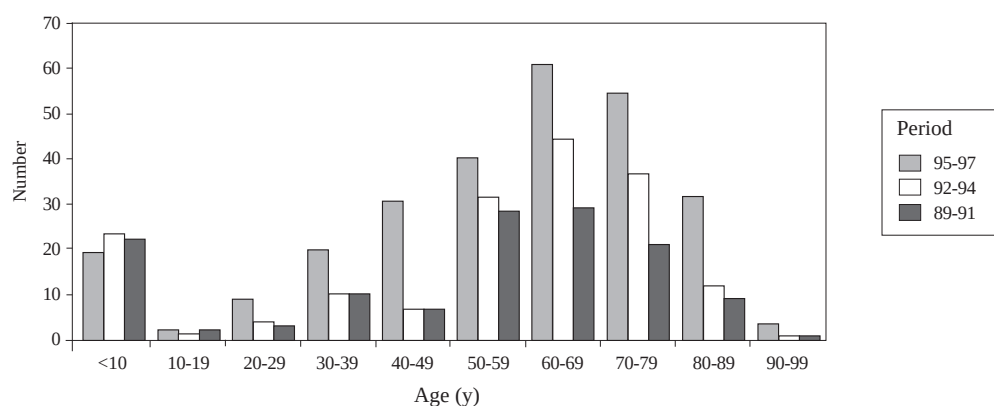


Fig. 1. Triennial age distribution.

triennia (Table II). Similarly, the relative proportions of deaths occurring peroperatively (intraoperatively) and within the first 24 hours of an operation were quite stable. However, it should be noted that more than half (51.2% to 56.7%) of these deaths had occurred after the first postoperative day.

Nature of Operation/Procedure

A total of 408 operations/procedures were performed, resulting in an average of 1.5 procedures per patient; this being reflected in the observation that over a third (101/270, 37.4%) of patients underwent 2 or more procedures (Fig. 2). A similar distribution was observed amongst patients aged 60 years, amongst whom an equivalent proportion (50/150, 33.3%) were subjected to more than one procedure.

Further analysis of these operations showed that just under half (129, 47.8%) of all patients initially underwent procedures classified by the respective operators as being emergencies, while a quarter (69, 25.6%) also had subsequent operations which were similarly classified. Again, there were similar proportions of patients who underwent further operations, following initial procedures classified as emergencies and electives (50/129, 38.8% versus 51/141, 36.2%).

Amongst the patients who underwent more than one procedure, 27 (26.7%) who initially had elective operations subsequently required emergency surgery or procedures,

while 42 (41.6%) of this sub-sample underwent a series emergency operations, both *ab initio* as well as subsequently (Table III). A poignant example of the former was that of a patient who had initially undergone sub-total gastrectomy for moderately differentiated gastric (antral) adenocarcinoma, who later required a series of 8 emergency operations to address a wide range of post-surgical complications arising from a consequence of anastomotic leakage from the gastrojejunostomy (Appendix I, Case 1).

Clinical Categories

The distribution of the clinical specialties involved, both initially and subsequently, was largely similar to that

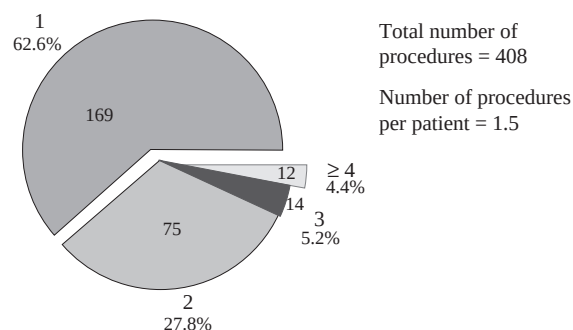


Fig. 2. Number of operations/procedure (1995 to 1997).

TABLE II: TRIENNIAL VARIATION IN THE POSTOPERATIVE INTERVAL (DAYS)

Period	1989 to 1991	1992 to 1994	1995 to 1997
Range	0 to 106	0 to 196	0 to 97
Median	1	1	1
Mean	5.7	6.7	4.2
Perioperative (%)	21 (16.0)	23 (13.5)	37 (13.8)
≤24 hours (%)	36 (27.3)	60 (35.3)	94 (34.9)

TABLE III: NATURE OF OPERATION/PROCEDURE (1995 TO 1997)

Classification (n = 270)	Initial	Subsequent
Emergency (%)	129 (47.8)	69 (25.6)
Elective (%)	141 (52.2)	32 (11.9)
Patients with >1 operation (n = 101)	Initial	
Subsequent	Emergency	Elective
Emergency	42	27
Elective	8	24

observed previously. Thus, during the current triennium, the surgical disciplines most commonly featured were cardiothoracic (21.5%), general surgery (19.3), hepatobiliary surgery (9.6%), orthopaedic surgery (8.9%) and neurosurgery (8.9%) (Fig. 3). Most patients (83.3%) were largely managed by one specialty and a minority by 2 (15.2%) or 3 (1.5%) specialties.

During this time, 4 deaths following laparoscopic surgery were reported, of which 3 involved laparoscopic cholecystectomy (one being a case of an iatrogenic death from septicaemia developing as a consequence of biliary leakage from the cystic duct stump), accompanied by a case of fatal pulmonary thromboembolism following laparoscopically-assisted vaginal hysterectomy.

Medico-legal Classification

The majority of deaths were considered to have been due to largely natural causes, with approximately equal proportions attributed to the underlying disease conditions (Category 1: 37.8%) and to co-morbidity (Category 2: 37.0%). There was a total of 66 (24.4%) iatrogenic deaths, of which 64 were due to non-anaesthetic surgical or interventional complications (Category 3), accompanied by 2 anaesthetic deaths (Category 4) (Fig. 4). In addition, there were 2 cases which could not properly be placed in any of the above categories. One of these involved a patient who suffered a fatal head injury when she fell off from her bed, apparently despite the bed rails being in place (Case 2); the other was a case of fatal peritonitis due to rectosigmoid perforation after a fleet enema was administered in a patient with anal stricture arising from previous radiotherapy for endometrial carcinoma, where it could not be determined if the perforation had preceded, or was the consequence of, the enema.

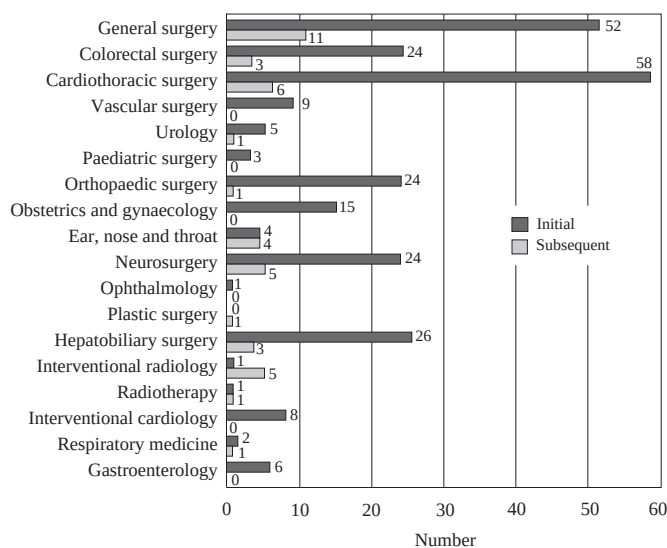


Fig. 3. Clinical categories—specialties (1995 to 1997).

Deaths from Co-morbidity

Co-morbidity accounted for 100 deaths, of which the majority (55) were attributed to cardiovascular causes (mostly cases of severe ischaemic heart disease, with 5 cases of viral myocarditis) and fatal pulmonary thromboembolism (23); the latter being suspected or diagnosed in only 7 cases. The remaining deaths in this category were due to bronchopneumonia (12), urinary tract infection (2), chronic obstructive airways disease (2) and other causes (4) such as malignancies and bowel infarction.

Iatrogenic Deaths

There was an apparent decrease in the proportion of iatrogenic deaths compared to the previous triennium (Table III) but the difference was not statistically significant. Analysis of the 64 non-anaesthetic iatrogenic deaths showed that haemorrhage (38) and infection (13) accounted for the majority of these cases, while the remaining deaths were due to operative visceral trauma (3), adverse drug reaction (1) and other causes (9) such as cerebral hypoxia and reflex cardiac inhibition. Vascular trauma and/or haemostatic failure and perioperative coagulopathy together accounted for most of the fatal haemorrhagic complications encountered (Table IV).

It was observed that although most of these deaths occurred peroperatively (intraoperatively) and within the first postoperative day, having accounted for approximately a third of all deaths during each of these periods (11/37 and 34/94, respectively), almost 14% (19/138) of deaths occurring after 24 hours of an operation were also iatrogenic in nature.

Not unexpectedly, the rate of non-anaesthetic iatrogenic deaths amongst patients undergoing multiple (>1) procedures was twice that of those who had only 1 procedure or operation (35.6% versus 16.6%). However, it was interesting and, somewhat surprising, to note that the iatrogenic death rate associated with elective procedures was 2 to 3 times higher than that arising from emergency operations (33.3% versus 13.2%) (Table V).

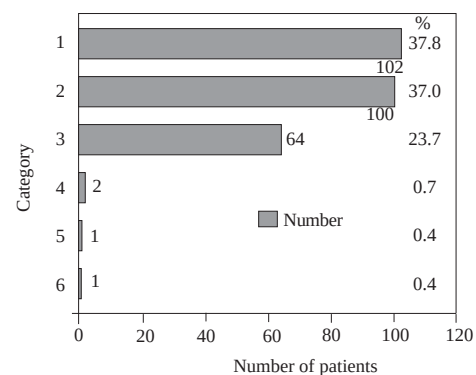


Fig. 4. Categories of death.

TABLE IV: DEATHS FROM HAEMORRHAGE AND INFECTION (1995 TO 1997)

Complications	No.
Perioperative haemorrhage	
Vascular trauma/haemostatic failure	15
Perioperative coagulopathy	15
Preoperative disposition	7
Other causes of haemorrhage	1
Perioperative infection	
Anastomotic breakdown, iatrogenic perforations, acute peritonitis, bronchopneumonia	9
Surgical wound infections; contamination of surgical prostheses, indwelling catheters, etc.	4

TABLE V: NON-ANAESTHETIC IATROGENIC DEATHS IN RELATION TO THE FREQUENCY AND NATURE OF PROCEDURES PERFORMED (1995 TO 1997)

	Category 3 deaths	All deaths	Proportion (%)
No. of procedures			
1	28	169	16.6*
>1	36	101	35.6*
Classification			
Emergency	17	129	13.2*
Elective	47	141	33.3*

* $P < 0.01$

There were only 2 anaesthetic deaths reported. One was due to a combination of bronchopneumonia and hypoxic encephalopathy, resulting from respiratory depression which was attributed to postoperative over-sedation. The other was the consequence of aspiration pneumonia arising from projectile bilious vomiting during induction of general anaesthesia (Cases 4 and 5).

Coroner's Verdicts

Almost all pathological assessments of deaths from natural causes were endorsed by the Coroner (200/202, 99.0%), with 2 cases receiving verdicts of misadventure. Thus, the convergence between the finding of a natural death by a pathologist and an identical Coroner's verdict observed in the previous triennia (93.3% and 97.3% during 1989 to 1991 and 1992 to 1994, respectively)^{1,2} was sustained. Similarly, the rather marked divergence between the attribution of deaths to iatrogenic causes, previously observed, was also striking, in that almost a quarter of such deaths were considered by the Coroner to be due to natural causes (11, 16.7%) or received open verdicts (4, 6.1%), while the remainder (51, 77.3%) were judged to be cases of misadventure. No verdict of criminal negligence was recorded during the period in question.

Discussion

A comparison of the data from the present review with that obtained previously clearly shows that there has been a steady triennial rise in the number of Coroner's perioperative autopsies conducted by the DFM from 1989 to 1997.

This trend has, notably, been sustained against a progressive decline in the total number of Coroner's autopsies over the same period, perhaps reflecting a greater awareness on the part of clinicians of the importance of reporting such deaths to the Coroner. While this observation may not actually denote an increase in perioperative deaths *per se*, it may be indicative of an increasingly "aggressive" or defensive approach to the clinical management of seriously ill and elderly patients, particularly over the past decade.

Thus, with respect to Coroner's cases, the author and his colleagues have observed that it is no longer uncommon for middle-aged or elderly patients with end-stage renal failure who have an increased risk of perioperative haemorrhage to undergo major surgery (such as anterior resection for rectosigmoid carcinoma). Similarly, a patient with a history of ischaemic heart disease (occurring against a background of diabetes mellitus, systemic hypertension and possibly, hyperlipidaemia), might first have his cardiovascular status "optimised" by means of coronary artery bypass grafting, prior to definitive colorectal surgery for colonic carcinoma. It has also been noted that for patients with obstructive jaundice arising from extrahepatic biliary lesions, who are concurrently septicaemic (with variable degrees of impaired liver function and coagulopathy) and judged to be too ill to undergo open or laparoscopic surgery, recourse to percutaneous transhepatic cholangiography (PTC) and drainage appears to be a rather attractive and popular alternative, particularly when earlier attempts at endoscopic retrograde cholangio-pancreatography had been unsuccessful. Of course, one should not overlook the fact that PTC, when indicated, is generally an effective and safe procedure.⁵

In the examples given above, it seems inevitable that the increased risk of fatal iatrogenesis (particularly haemorrhagic complications) will eventually materialise, quite possibly to the dismay of the surgeons or interventionists involved, only to be further complicated by allegations of sub-optimal treatment, or even of negligence, on the part of the bereaved families. This is a situation which seems to be occurring with increasing frequency, seemingly in tandem with the multiplicity of investigative and therapeutic or palliative procedures which are now commonplace.

Although the frequency of iatrogenic deaths in the current review was lower than that observed in the previous triennium² (24.4% versus 28.8%), this was not statistically

significant and was still considerably higher than that observed during the first triennium (15.2%).¹ It is too early to conclude that the apparent stabilisation of the iatrogenic death rate will persist. Furthermore, not all perioperative deaths are reported to the Coroner and those that are may well represent a somewhat skewed sample of some of the most serious or diagnostically puzzling cases, where death was either unexpected or preceded by a sequence of unfortunate clinical events. Comparative statistics from other sources are extremely difficult to obtain, as few medico-legal jurisdictions outside Singapore actually collate the occurrence of iatrogenic perioperative deaths for the purpose of on-going systematic analysis. As noted previously,¹ most studies on perioperative deaths tend to be focused on the identification of avoidable and unavoidable deaths and the determination of overall, avoidable and procedure-specific perioperative mortality rates, and rarely deal with iatrogenic deaths *per se*. Indeed, even an organisation such as the National Confidential Enquiries into Perioperative Deaths (UK), which is wholly dedicated to the study of perioperative mortality, is almost exclusively concerned with the quality of surgical care and, hence, the identification of remediable factors in the cases which are voluntarily presented to it for collection and peer review, rather than the causes or the nature of such deaths.

As an extension of previous endeavours, the present review included a further analysis of iatrogenic deaths identified. The frequency amongst patients subjected to multiple procedures was twice as high as that amongst patients who underwent only 1 procedure, (35.6% versus 16.6%). However, it was not possible to determine the corresponding cumulative risk for each additional procedure performed (ideally corrected for age, sex, case-mix, comorbidity and other confounding factors), due to the relatively small size of this sub-sample. Arguably, it could be taken as evidence that the risk of iatrogenic injury increases with the number of interventions performed, without any implied judgement on their indication or necessity.

While this seems to be stating the obvious, especially when over a third (37.4%) of all the patients in the current review had 2 or more procedures each, what was surprising was the additional finding that the iatrogenic death rate associated with elective procedures (as classified by the operators themselves) was almost 3 times higher than that arising from emergency procedures (33.3% versus 13.2%). This is indeed an intriguing observation, if one were to assume that, on the whole, elective procedures tend to be performed on clinically stable patients, or at the very least, are generally undertaken after thorough investigations and efforts to “optimise” them preoperatively. Accordingly, such patients should have had a better survival advantage over their counterparts who were managed for acute

conditions. Moreover, as demonstrated, similar proportions of patients who had undergone emergency and elective procedures initially, subsequently required further operations, effectively excluding any difference in the frequency of multiple interventions in both these groups as a putative cause. Of course, the confounding factors previously mentioned, as well as the possibility that the elective procedures may have been more complex than those performed in emergencies, may have partly been responsible for this unexpected outcome. Nevertheless, further inquiry into this issue is clearly warranted.

Whatever the reasons for this observation may be, it seems imperative that the occurrence of iatrogenic injuries, whether fatal or otherwise, be properly accounted for. This has assumed particular importance, not least because there have been no lack of studies demonstrating that iatrogenic complications account for many deaths, long-term disabilities and avoidable expense.⁶ Thus, it has been estimated that 5% to 13% of hospital admissions result from the adverse effects of diagnosis or treatment, while up to 70% of iatrogenic complications are preventable.^{7,8} There appears to be a tendency for secular media coverage of these unfortunate events, both locally and elsewhere, to assume a manner that calls to question the professional competence of the attending clinicians, whether justifiably or otherwise, whenever medical errors are publicised. Admittedly, even relatively staid case reports of unusual perioperative complications appearing in biomedical journals⁹⁻¹¹ might appeal to the imagination. Nevertheless, while human agency is, undoubtedly, the immediate cause of iatrogenesis or lapses in patient care, it should be acknowledged that systemic failure and poor system or job design may account for almost 80% of harmful errors, by providing conditions (such as unfavourable institutional staffing policies) under which errors will thrive.¹²⁻¹⁴

Therefore, efforts to minimise the occurrence of perioperative iatrogenic injuries should not be limited to improvements in surgical skill and training; anaesthesia; preoperative, postoperative and intensive care; patient selection; clinical guidelines or pathways; or advances in biomedical technology,¹⁵⁻²⁷ important as these and other related matters are, but should also address systemic issues within specific healthcare settings. Failure to do so may have disastrous results, as the vignette regarding an anaesthetic death (Case 4) amply illustrates.

Given the fact that, consistently, over half of the subjects of perioperative deaths reported to the Coroner were aged 60 years or older, with a significant peak (20% to 25%) in the seventh decade, it should be asked whether a more conservative approach to patient selection for invasive procedures ought to be considered. Indeed, it has been said that the ability to recognise when surgery is “too

adventurous, ill advised or futile, given the condition of the patient” is itself a surgical skill.²⁸ In fairness, it should also be acknowledged that it is often difficult for surgeons to resist pressure from patients, their relatives or even medical colleagues to operate;^{28,29} a comment which might also apply to other clinicians, such as interventional radiologists and cardiologists, as well as respiratory physicians, who perform invasive procedures. It has also been emphasised that, even when surgery is indicated, elderly patients have a poor tolerance for repeated episodes of preoperative starvation, prolonged pain, sepsis and immobility and that close attention to adequate fluid management is essential.^{20,21,30} The critical question in all cases, particularly from the medico-legal perspective, is whether the decision to operate is in the patient’s best interest.

With respect to the reporting of perioperative deaths to the Coroner, a guiding principle is that any death which has occurred at any time during or after any invasive procedure (whether diagnostic or therapeutic in nature) should be regarded as reportable if an iatrogenic cause cannot reasonably be excluded, even if it should occur after 24 hours of a procedure. This is borne out by the observation that, although the majority of iatrogenic deaths occurred within the first postoperative day, they also accounted for 14% of later deaths.

It should be emphasised that guidelines on reportable cases (Appendix II), drafted and periodically updated by the DFM on behalf of the Ministry of Health, which then circulates them to the various public and private hospitals, should be made available to all medical and nursing staff. In addition, forensic pathologists are usually available to advise clinicians on the reportability of actual cases. Although the increasing perioperative necropsy rate might be taken to indicate more conscientious reporting of such deaths, the author has noticed what might be an emerging trend of some clinicians approaching forensic pathologists for advice on this matter and then, subsequently, declining to report cases which are clearly or probably iatrogenic in nature, or where death was sudden, apparently unexplained and unexpected. It is possible that in such cases the clinicians concerned had, instead, succumbed to pressure from the bereaved families to issue death certificates, which would, presumably, have indicated natural causes of death. Arguably, this would amount to making false declarations and, moreover, failure to report a reportable death to the Coroner may (and has) landed some doctors in serious trouble with the relevant authorities. This begs the question of whether the existing guidelines should be rendered more stringent and, perhaps, be reinforced by legislation.

Quite apart from fatal iatrogenic injury, there was a substantial number of deaths from co-morbidity. It is significant that 23 of the 100 deaths in this category were

caused by fatal pulmonary thromboembolism, which was suspected or diagnosed in only 7 cases (30.4%). This is in keeping with an earlier local study on the subject that showed that the index of suspicion for this condition was very low; it being completely unsuspected in 77% of a series of 116 necropsies.³¹ Perhaps the striking concordance between the findings of that study and the present one should prompt a further review of this fascinating subject. It is also proposed that future reviews of perioperative deaths (perhaps more aptly renamed “peri-procedural” deaths to include most forms of invasive interventions which are performed by clinicians other than surgeons) should focus primarily on the role of co-morbidity in the causation of death, as well as its interaction with, and relation to, fatal iatrogenic complications.

The divergence between the post-mortem assessment of a death as being due to an iatrogenic injury from a Coroner’s finding of misadventure was observed previously.² This could, in large part, be attributed to the fact that in a substantial proportion of these cases, the contribution of iatrogenesis to the causation of death was deemed to be relatively minor and that, for reasons of medico-legal expedience, death could be considered to be due to either the condition which necessitated the operation, or to co-morbidity, rather than to the intervention itself.

It might be of interest to clinicians to note that independent clinical experts (that is, relevant senior specialists who were not involved in the patients’ management and who were from institutions or in practices other than that where the perioperative deaths had occurred) were engaged by the State Coroner in no less than 11 cases during the period in question. A case of death following spinal surgery, in particular, required the services of three experts, each representing different clinical disciplines. All of them were essentially required to undertake what would amount to a peer review of the clinical management in each of these cases. Although some were critical of certain aspects of patient care, thereby implying that it was sub-optimal, or that an error of judgement had been made, none would give an unequivocal opinion that the attending doctors were negligent. Therefore, it is hardly surprising that no verdict of criminal negligence was recorded during this time, although it would appear that, but for a technicality, an adverse verdict of this nature might have been returned on an anaesthetic death.

Finally, it should be said that the importance of arriving at a realistic appraisal of the inherent risks of any invasive diagnostic or therapeutic procedure cannot be over emphasised. It has been observed that, not uncommonly, miscommunication or misapprehension of the actual risks and potential benefits of any proposed procedure in a given case may result in largely avoidable allegations of medical

negligence.

Certainly it may be difficult for a patient to appreciate that laparoscopic cholecystectomy, which is frequently performed and has largely replaced its conventional counterpart and is generally a safe and effective procedure in experienced hands, may occasionally result in bile duct injuries or cystic leakage from the cystic duct stump, the symptoms of which may be delayed for several days.³²⁻³⁵ Also the creation of a carbon dioxide pneumoperitoneum, common to most laparoscopic procedures, may itself be complicated by a reduction in cardiac output and diminished splanchnic, hepatic and renal blood flow through a combination of mechanical compression and humoral (neuroendocrine and metabolic) factors, thereby predisposing to bowel ischaemia and renal dysfunction.³⁶⁻⁴⁰ Patients should know that even though the risk is $\leq 1\%$, it will eventually materialise.

Similarly, it might be difficult to explain, satisfactorily, to the bereaved relatives, how it came to be that diagnostic colonoscopy for the investigation of chronic diarrhoea or suspected colorectal carcinoma, could have caused sudden perioperative death, presumably through reflex cardiac inhibition, when the associated risk of an iatrogenic perforation may be as low as 0.1% .⁴¹⁻⁴³

Indeed, it has been suggested that the term “minimally invasive surgery” be replaced by “minimal access surgery” as the later is semantically more accurate, since the invasion is absolute and such interventions are as invasive as open surgery in their capacity to reach various organs and tissues. Furthermore, it is argued, the former tends to connote increased safety, when in fact, it may not be minimally stressful to the patient.^{28,40}

Undoubtedly, advising patients on the inherent risks of the procedures that have been proposed to them in a manner that they could understand, without them being unduly alarmed by the information, is hardly ever an easy task. Yet, it is vital that patients are effectively apprised of the risks of the interventions to which they have consented. This is admittedly a tedious, but necessary process which may entail much patience and repetition on the part of the overworked and harassed clinician. Therein lies what may, perhaps, be a most perplexing conundrum in modern medical practice.

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Appendix I: Vignettes of Cases of Medico-legal Significance

Case 1

A 79-year-old Chinese female underwent subtotal gastrectomy for antral carcinoma, following which she was re-operated a total of eight times for postoperative pancreatitis and anastomotic breakdown of the gastro-jejunostomy, in the space of a month. She became severely septicaemic, having to undergo cholecystectomy for a perforated gallbladder towards the end of her stormy perioperative course.

A senior consultant surgeon, engaged as an independent expert by the coroner's court, opined that critical management decisions are difficult to make in respect of the severe intra-abdominal sepsis resulting from postoperative anastomotic leakage. He was of the view that all the leaks found on the anastomotic line were likely to have been caused by technical errors, as evidenced by their presence only in the stump and not at the other suture lines. Hence, the leaks could not be attributed to age or poor blood supply, infection or other factors; their early occurrence (shortly after the operation) would, in fact, be indicative of technical error. He added that there appeared to be a certain degree of carelessness involved in stapling the suture line and stitching might have been more appropriate. However, although critical of the overall management of the patient in this particular instance, he was of the view that there was no evidence of overt mismanagement or negligence on the part of the attending doctors.

Coroner's verdict: Misadventure.

Case 2

An 81-year-old Chinese female sustained a fatal head injury when she fell from her bed, a day after elective correction of bilateral upper eyelid entropion, performed under local anaesthesia. She was also concurrently diagnosed with low tension glaucoma and had undergone bilateral cataract operations two years ago.

An urgent CT scan apparently showed the presence of a right occipital fracture, adjacent to which was a small extradural haematoma, together with subarachnoid haemorrhage and a right intra-cerebellar haematoma. A neurosurgical opinion was sought and, in consultation with the family, it was finally decided that, given the poor surgical risk and likely outcome due to the patient's age there should be no further intervention.

Autopsy confirmed the presence of the right occipital fracture (measuring 8 cm in length) and subarachnoid haemorrhage, and further demonstrated the presence of acute subdural haemorrhage extending from the posterior to the middle cranial fossae, together with a cortical laceration of the right cerebellar hemisphere, with no evidence of any intracerebellar haemorrhage. The intracranial injuries were clearly traumatic in nature and the possibility of a spontaneous intracerebellar haemorrhage (i.e. a cerebrovascular accident leading to the fall and, hence, the fatal head injury) was largely excluded.

It appears that, in this case, the resident on-call did not

personally attend to the patient promptly, when alerted of her fall and progressively worsening condition, despite having been paged repeatedly by the nursing staff, whom he had initially instructed to monitor the patient with the aid of a head chart. When he finally examined the patient, some 2 hours after the fall, the latter was already in a critical condition. Subsequently, an internal hospital inquiry exonerated both the nursing and medical staff on duty at the time, apparently having accepted the consultant neurosurgeon's opinion that the delay in attending to the patient would not have altered the outcome. A coroner's inquiry returned a verdict of misadventure.

Case 3

A 54-year-old Chinese male was diagnosed with advanced adenocarcinoma of the gallbladder with biliary obstruction. He underwent cholecystectomy, and extensive liver resection (right hepatic lobe and segment 4A), with transection of the right branch of the portal vein; peroperatively, it was observed that the carcinoma had invaded the common bile and hepatic ducts, the right hepatic duct and the portal vein.

Postoperatively, he was initially well, apart from a mild methicillin-resistant *Staphylococcus aureus* (MRSA) wound infection, which was effectively treated with antibiotics. However, his condition deteriorated on the eighth postoperative day, when hypotension, respiratory distress and renal impairment set in. An abdominal CT scan and an angiogram showed portal vein thrombosis. On the tenth postoperative day, portal vein thrombectomy and reconstruction with a graft venous patchy were performed, during which the patient developed disseminated intravascular coagulation, having lost approximately 6 litres of blood in the process. During the second operation, a defect in the preserved part of the main portal vein was noted. Subsequently, whilst in the surgical intensive care unit, he underwent massive transfusions of blood (25 units of whole blood), platelets (10 units) and fresh frozen plasma (7 litres). However, he died the following day.

Following autopsy, the cause of death was certified as being due to severe intra-abdominal haemorrhage following extensive surgery for advanced carcinoma of the gallbladder.

The independent clinical expert for this case (a senior consultant hepatobiliary surgeon) opined that it was essentially a matter of fine clinical judgement as to whether such extensive surgery was indicated, particularly in view of carcinomatous invasion of the portal vein. He was also of the view that, although the patient would probably have benefited from earlier portal vein thrombectomy, the second operation would have been a very risky one and, as such, the delay incurred in confirming the diagnosis by means of an angiogram was justified.

The Coroner recorded a verdict of misadventure.

Case 4

A 36-year-old female with Down's syndrome underwent elective total hysterectomy (with left salpingo-oophorectomy)

for the management of poor menstrual hygiene. The operation was uneventful, but postoperatively, she was heavily sedated with intravenous midazolam and continuous morphine infusion.

On the first postoperative day, she collapsed on the ward and was diagnosed with hypoxic encephalopathy. Subsequently, she acquired various nosocomial respiratory infections (including MRSA) and died 3½ months later. Autopsy confirmed that the cause of death was due to a combination of bronchopneumonia and hypoxic encephalopathy.

At the Coroner's inquiry, the consultant anaesthetist-in-charge was named as the potential defendant and two independent clinical experts were engaged. The following lapses of care were identified:

- (a) failure to appreciate the clinical significance of a low sedation score, at least on the part of the nursing staff assigned to monitor the patient during the immediate postoperative period;
- (b) failure of communication amongst the medical and nursing staff involved in the clinical management of the patient;
- (c) failure to recognise the likelihood of a patient with Down's syndrome being particularly sensitive to morphine and sedative drugs, who is thus prone to respiratory depression from a combination of over-sedation (even when these are given in their normal dosages) and upper airway obstruction (due to the presence of a large tongue); and
- (d) failure to manage such a patient with a commensurate degree of care (despite the use of sedation and pain scores and other hourly parameters) and to titrate the dose of morphine infusion accordingly (as evidenced by the fact that the patient received continuous morphine infusion, consistently at a rate of 1.5 mg/h, over a period of some 8 hours, postoperatively, and by the lack of SaO₂ monitoring for over 5 hours during this time).

The Coroner concluded that although the patient was likely to have suffered desaturation, postoperatively, it was not possible to particularise the time at which the deceased sustained irreversible hypoxic brain damage. An open verdict was returned.

Case 5

A 64-year-old Chinese male underwent emergency laparotomy, with right hemicolectomy and ileostomy, for caecal perforation associated with a pericaecal mass (most probably due to appendicitis). He was re-admitted some 3 months later for elective ileo-colic anastomosis, which was performed satisfactorily.

As he had difficulty voiding postoperatively, flexible cystoscopy, with urinary catheterisation, was performed on the second postoperative day. This showed evidence of bladder neck stenosis, whereupon transurethral resection of the bladder neck (TURBN) was done on the 10th postoperative day. Unfortunately, projectile bilious vomiting occurred during induction of general anaesthesia, with resultant aspiration

pneumonia which eventually led to the patient's demise 2 days after bladder neck surgery. Autopsy showed confluent areas of severe consolidation of the right and left lungs, which weighed 1100 g and 1150 g, respectively (or approximately 3 to 4 times their normal weights).

The independent clinical expert (a senior consultant anaesthetist) for this case initially found it difficult to determine if mismanagement was the cause of the development of aspiration and its sequelae and, ultimately, of death. This was largely because documentation by the attending surgeon and anaesthetist was incomplete; the anaesthetic procedure having been recorded as a summary, which omitted some of the crucial time-related anaesthetic events. He subsequently raised a series of questions, concerning the anaesthetic procedure and the clinical management of the patient in the surgical intensive care unit, to the attending anaesthetist, through the investigating officer, and eventually concluded that there was no negligence on the part of the anaesthetist, who apparently answered his queries satisfactorily.

The Coroner recorded a verdict of misadventure.

Case 6

A 35-year-old Chinese female was diagnosed with transsexuality, associated with probable schizo-affective and personality disorders, over a period of some 14 years previously. She had bilateral mastectomy approximately 5 years ago, followed by sex re-assignment surgery, comprising abdominal total hysterectomy and bilateral salpingo-oophorectomy and raising of the penile pedicle (in preparation for the subsequent insertion of a penile prosthesis).

During the last operation, blood loss was estimated to be circa 3.2 L and she was transfused with 2 units of blood peroperatively (intraoperatively). Surgery was otherwise uneventful and she appeared to be well when reviewed some 4 hours postoperatively. However, 4 hours later she collapsed and died despite vigorous cardiorespiratory resuscitation, approximately 9 hours after the operation.

No natural cause of death was found at autopsy and post-mortem toxicological analysis was performed without significant results. It was thought that the perioperative blood loss might have at least contributed to her death.

A senior consultant obstetrician and gynaecologist in private practice, who was engaged by the Coroner's court as an independent clinical expert, opined that there was no negligence on the part of the principal gynaecologist who performed the sex re-assignment operation.

An open verdict was returned.

Case 7

A 40-year-old Chinese female underwent cystectomy for a right ovarian endometriotic cyst. The operation was carried out satisfactorily, but on the second postoperative day, she complained of abdominal pain, which she attributed to "severe wind". The following day, abdominal distension was noted and a fleet enema was administered, without relief. The

patient subsequently became distressed and hypotensive. She collapsed and died later that day despite prolonged and aggressive resuscitation.

Autopsy showed evidence of acute suppurative peritonitis (comprising 1 L of turbid peritoneal fluid), with no evidence of any significant intra-abdominal haemorrhage or visceral perforation.

The independent clinical expert (a senior obstetrician and gynaecologist) postulated that the patient might have succumbed to Toxic Shock Syndrome caused by Group A Streptococci infection, which is often not associated with a definite portal of entry. He opined that the operation was indicated and that there was no negligence on the part of the attending gynaecologist.

An open verdict was recorded.

Case 8

A 57-year-old Chinese female was admitted for the management of acute epiglottitis with laryngeal stridor. She had a history of systemic hypertension, diabetes mellitus, bronchial asthma, a recent cerebrovascular accident and epilepsy (on treatment with phenytoin), and was severely obese (body mass index at autopsy: 38.3 kgm⁻²). Emergency tracheostomy was performed under general anaesthesia with some difficulty. During the procedure, it was observed that the patient had a short neck and that the trachea was small; also, the epiglottis and pharynx were severely oedematous. She was then transferred to the surgical intensive care unit (SICU) for postoperative ventilation.

Some 4 hours after the operation, the patient developed surgical emphysema, compounded by respiratory distress and cyanosis when the attending ENT surgical registrar decided to place the patient on spontaneous respiration with a tracheostomy mask, during which the ventilator was disconnected. A subsequent attempt at passing a soft tip suction catheter through the tracheostomy tube failed. The surgeon then proceeded to remove the existing tube and attempted to insert a new one in its place without success. During this time, the patient went into cardiac arrest and died 5 hours after the operation.

A senior consultant ENT surgeon, who was engaged on behalf of the State Coroner as an independent clinical expert, opined that the most likely cause of the postoperative surgical emphysema was slippage of the tracheostomy tube, but did not consider the failed attempt at changing the tracheostomy tube in the SICU to be in any way negligent.

A verdict of misadventure was recorded.

Case 9

A 55-year-old Chinese female was diagnosed with a malignant neoplasm of the extrahepatic bile ducts, on endoscopic retrograde cholangiopancreatography, which showed an irregular filling defect in the distal part of the common bile duct (CBD), compatible with a carcinoma. Subsequently, she underwent a Whipple's operation and

appeared to be recovering well from surgery, when she collapsed unexpectedly and died suddenly on the ninth postoperative day, at which point massive pulmonary embolism was suspected.

Autopsy showed evidence of acute peritonitis (comprising 250 mL of faeculent fluid) attributable to a 1-cm long, anastomotic breakdown of the pancreatico-jejunostomy. No pulmonary thromboembolism was found. Interestingly, perioperative frozen section biopsies of the distal part of the CBD (which was indurated) showed no evidence of malignancy; the absence of which was later confirmed by histological examination of the entire Whipple's resection specimen that demonstrated the presence of a mildly dysplastic, adenomatous polyp arising from the Ampulla of Vater instead.

A verdict of misadventure was returned.

Case 10

A 36-year-old Chinese female underwent extrapleural pneumonectomy for mesothelioma of the left chest. The operation appeared to have proceeded smoothly and the patient was in a stable condition until the third postoperative day when the patient became hypotensive, requiring blood and fluid infusions.

Eventually, exploratory thoracotomy was performed, whereupon 1 L of blood was found in the left pleural cavity, together with a small rupture (0.5 mm) in the left wall of the descending thoracic aorta, a short distance from the diaphragmatic hiatus. This injury, which was later thought to have inadvertently been induced by diathermy, was repaired, together with a 3-cm laceration in the anterior wall of the right ventricle, attributed to resuscitation carried out when the patient collapsed in the operating theatre just before the second operation commenced.

The operative findings were verified by the subsequent autopsy, which showed the presence of 1.1 L and 450 mL of heavily blood-stained fluid in the left pleural and peritoneal cavities, respectively. It also demonstrated dehiscence of the prolene mesh which replaced the left hemi-diaphragm that had been removed during the first operation. Again, this observation was thought to be consistent with an artefact of resuscitation.

The independent clinical expert in this case agreed that the rupture in the descending aorta was most likely due to a diathermy burn, which would have been difficult to detect, being an unusual, but known, risk of such an operation. He was of the view that it would have been improbable for the aorta to have been damaged during the subsequent postoperative clamping and unclamping of the chest drainage tubes, performed by the nursing staff on the instructions of the principal surgeon for periodic drainage of the left chest cavity. This matter was brought up during the inquiry, as it was a point of contention on the part of the bereaved husband, who felt that the patient had been transferred out of intensive care into the high dependency unit (on the second postoperative day) prematurely and had alleged that, at some stage, there was

unauthorised unclamping of the drainage tubes by the nursing staff. He was thus of the view that the patient had been mismanaged and threatened civil action.

In the event, the Coroner returned a verdict of misadventure, having accepted expert testimony that surgery had been performed appropriately and in accordance with accepted medical practice. It was also emphasised that an examination of the nursing notes showed no evidence of the alleged unauthorised unclamping of the chest tube at the material time.

Appendix II: Guidelines on the Reporting of Deaths to the Coroner*

The death of any person:

1. known, or likely, to have been due to, or the consequence of, any violent or unnatural event or cause, such as
 - a) homicide;
 - b) suicide;
 - c) domestic, industrial, road or any other accident;
 - d) drowning;
 - e) asphyxia and choking; including aspiration pneumonia following the inhalation of foreign bodies;
 - f) electrocution or lightning strike;
 - g) burns and scalds;
 - h) poisoning;
 - i) drug overdose;
 - j) adverse drug and or transfusion reactions; including anaphylaxis, toxic epidermal necrolysis, Steven-Johnson's syndrome, neuroleptic malignant syndrome, etc;
 - k) infection following any form of injury or unnatural event;
 - l) pneumoconiosis, or any other occupational diseases, and
 - m) want, neglect or exposure;
2. *that occurred during, or at any time after any operation, or any invasive diagnostic or therapeutic procedure, or any medical intervention, if death may be deemed, in any way, to have been caused, or contributed to, by any such procedure or treatment;***
3. that occurred during pregnancy or childbirth (including Caesarean and assisted delivery) or an induced abortion;
4. that occurred whilst in statutory care, custody, or detention (this does not apply to person who had been admitted to a nursing home, or otherwise institutionalised, on a *voluntary basis*, provided the cause of death is natural);
5. brought in dead to a hospital or clinic, when the cause of death is unknown and unnatural causes cannot be excluded;
6. who has not been identified;
7. that occurred under suspicious circumstances.

* as at June 1999

** this is the principal guideline concerning perioperative and iatrogenic deaths (author's emphasis)

REFERENCES

1. Lau G. Perioperative deaths in Singapore: a forensic perspective in a study of 132 cases. *Ann Acad Med Singapore* 1994; 23:351-7.
2. Lau G. Perioperative deaths: a comparative study of coroner's autopsies between the periods of 1989-1991 and 1992-1994. *Ann Acad Med Singapore* 1996; 25:509-15.
3. Knight B. Forensic pathology. Kent: Edward Arnold, 1991:434-40.
4. Knight B. Forensic pathology. 2nd ed. London: Arnold, 1996:475-81.
5. Funaki B, Zaleski G X, Straus C A, Leef J A, Funaki A N, Lorenz J, et al. Percutaneous biliary drainage in patients with non-dilated intra-hepatic bile ducts. *AJR Am J Roentgenol* 1999; 173:1541-4.
6. Hart G K. Error in medicine: adverse events in intensive care. *Schweiz Med Wochenschr* 1999; 129:1583-91.
7. Sharpe V A, Faden A I. Medical harm: historical, conceptual, and ethical dimensions of iatrogenic illness. Cambridge: Cambridge Univ Press, 1998:1-14.
8. Brennan T A, Leape L L, Laird N M, Hebert L, Localio A R, Lawthers A G, et al. Incidence of adverse events and negligence in hospitalized patients. Results of the Harvard Medical Practice Study I. *N Engl J Med* 1991; 324:370-6.
9. Davies J S, Scanlon M F. Hypopituitarism after coronary artery bypass grafting. *BMJ* 1998; 316:682-5.
10. Lau G, Tan S Y, Chiang G, Poh W T. Bronchioloalveolar carcinoma with metastasis to the pituitary gland: a case report. *J Clin Pathol* 1998; 51:931-4.
11. Veijola M, Ikaheimo M, Valkama J, Hirvonen J. Fatal occlusion of the left coronary main stem by a fragment from the femoral artery: a previously unreported complication of cardiac catheterization. *Forensic Sci Int* 1997; 88:111-6.
12. Sharpe V A, Faden A I. Medical harm: historical, conceptual, and ethical dimensions of iatrogenic illness. Cambridge: Cambridge Univ Press, 1998:137-40.
13. Wu A W, Folkman S, McPhee S J, Lo B. Do house officers learn from their mistakes? *JAMA* 1991; 265:2089-94.
14. Leape L L, Bates D W, Cullen D J for the Adverse Drug Event Prevention Study Group. Systems analysis of adverse drug events. *JAMA* 1995; 274:35-43.
15. Treasure T, Bennett D. Reducing the risk of major elective surgery. *BMJ* 1999; 318:1087-8.
16. Wilson J, Woods I, Fawcett J, Whall R, Dibb W, Morris C, et al. Reducing the risk of major elective surgery: randomised controlled trial of preoperative optimisation of oxygen delivery. *BMJ* 1999; 318:1099-103.
17. Levi M, Cromheecke M E, de Jonge E, Prins M H, de Mol B J M, Briet E, et al. Pharmacological strategies to decrease excessive blood loss in cardiac surgery: A meta-analysis of clinically relevant endpoints. *Lancet* 1999; 354:1940-7.
18. O'Leary M, Bihari D. Central venous catheters—time for a change? *BMJ* 1998; 316:1918-9.
19. Sonksen J, Gray R, Hickman P H. Safer non-cardiac surgery for patients with coronary artery disease. *BMJ* 1998; 317:1400-1.
20. Sinclair S, James S, Singer M. Intraoperative intravascular volume optimisation and length of hospital stay after repair of proximal femoral fracture: randomised controlled trial. *BMJ* 1997; 315:909-12.
21. Lane N, Allen K. Hyponatraemia after orthopaedic surgery. *BMJ* 1999; 318:1363-4.
22. Aitken R J, Thompson M R, Smith J A E, Radcliffe A G, Stamatakis J D, Steele R J C. Training in large bowel cancer surgery: observations from three prospective regional United Kingdom audits. *BMJ* 1999; 318:702-3.
23. Hasan A, Pozzi M, Hamilton L. New surgical procedures: can we minimise the learning curve? *BMJ* 2000; 320:171-3.
24. Woolf S H, Grol R, Hutchinson A, Eccles M, Grimshaw J. Potential benefits, limitations and harms of clinical guidelines. *BMJ* 1999; 318:527-30.
25. Shekelle P G, Woolf S H, Eccles M, Grimshaw J. Developing guidelines. *BMJ* 1999; 318:593-6.
26. Hurwitz B. Legal and political considerations of clinical practice guidelines. *BMJ* 1999; 318:661-4.
27. Feder G, Eccles M, Grol R, Griffiths C, Grimshaw J. Using clinical guidelines. *BMJ* 1999; 318:728-30.
28. Ferriman A. Surgeons carry out too many operations on dying patients. *BMJ* 1998; 317:1269.
29. The Report of the National Confidential Enquiry into Perioperative Deaths (1 April 1997 to 31 March 1998). London: National Confidential Enquiry into Perioperative Deaths, 1999.
30. Knietowicz A. Call for greater care of elderly people in surgery. *BMJ* 1999; 319:1324.
31. Lau G. Pulmonary thromboembolism is not uncommon—results and implications of a five-year study of 116 necropsies. *Ann Acad Med Singapore* 1995; 24:356-65.
32. Woods M S, Shellito J L, Santoscoy G S, Hagan R C, Kilgore W R, Traverso L W, et al. Cystic duct leaks in laparoscopic cholecystectomy. *Am J Surg* 1994; 168:560-3.
33. Wise U S, Glick G L, M Landeros. Cystic duct leak after laparoscopic cholecystectomy. A multi-institutional study. *Surg Endosc* 1996; 10:1189-93.
34. Barkun A N, Rezieg M, Mehta S N, Pavone B, Landry S, Barkun J S, et al. Postcholecystectomy biliary leaks in the laparoscopic era: risk factors, presentation and management. *Gastrointest Endosc* 1997; 45: 277-82.
35. Adamsen S, Hansen O H, Funch-Jensen P, Schulze S, Stage J G, Wara P. Bile duct injury during laparoscopic cholecystectomy: a prospective nationwide series. *J Am Coll Surg* 1997; 184:571-8.
36. Paul A, Troidl H, Peters S. Fatal intestinal ischaemia following laparoscopic cholecystectomy. *Br J Surg* 1994; 81:1207.
37. Punnonen R, Viinamaki O. Vasopressin release during laparoscopy: role of increased intra-abdominal pressure. *Lancet* 1982; i:175-6.
38. Ishizaki I, Bandai I, Shimomura K, Abe H, Ohtomo I, Idezuki I. Changes in splanchnic blood flow and cardiovascular effects following peritoneal insufflation. *Surg Endosc* 1993; 7:420-3.
39. Caldwell C B, Ricotta J J. Changes in visceral blood flow with elevated intra-abdominal pressure. *J Surg Res* 1987; 43:14-20.
40. Cuschieri A. Technology for minimal access surgery. *BMJ* 1999; 319:1304.
41. Hall C, Dorricott N J, Donovan I A, Neoptolemos J P. Colon perforation during colonoscopy: surgical versus conservative management. *Br J Surg* 1991; 78:542-4.
42. Christie J P, Marrazzo J. "Mini-perforation" of the colon—not all postpolypectomy perforations require laparotomy. *Dis Colon Rectum* 1991; 34:132-5.
43. Farley D R, Bannon M P, Zietlow S P, Pemberton J H, Illstrup D M, Larson D R. Management of colonoscopic perforations. *Mayo Clin Proc* 1997; 72:729-33.