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Preventable mortality after common urological surgery: failing to rescue?

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Objective

To assess in-hospital mortality in patients undergoing many commonly performed urological surgeries in light of decreasing nationwide perioperative mortality over the past decade. This phenomenon has been attributed in part to a decline in 'failure to rescue' (FTR) rates, e.g. death after a complication that was potentially recognisable/preventable.

Patients and Methods

Discharges of all patients undergoing urological surgery between 1998 and 2010 were extracted from the Nationwide Inpatient Sample and assessed for overall and FTR mortality. Admission trends were assessed with linear regression. Logistic regression models fitted with generalised estimating equations were used to estimate the impact of primary predictors on over-all and FTR mortality and changes in mortality rates.

Results

Between 1998 and 2010, an estimated 7 725 736 urological surgeries requiring hospitalisation were performed in the USA; admissions for urological surgery decreased 0.63% per year ($P = 0.008$). Odds of overall mortality decreased slightly (odds ratio [OR] 0.990, 95% confidence interval [CI] 0.988–0.993), yet the odds of mortality attributable to FTR increased 5% every year (OR 1.050, 95% CI 1.038–1.062). Patient age, race, Charlson Comorbidity Index, public insurance status, as well as urban hospital location were independent predictors of FTR mortality ($P < 0.001$).

Conclusion

A shift from inpatient to outpatient surgery for commonly performed urological procedures has coincided with increasing rates of FTR mortality. Older, sicker, minority group patients and those with public insurance were more likely to die after a potentially recognisable/preventable complication. These strata of high-risk individuals represent ideal targets for process improvement initiatives.

Keywords

urological surgery, failure to rescue, preventable mortality

Introduction

The 'To Err is Human' report published by the Institute of Medicine [1] highlighted significant concerns for patient safety in USA hospitals. Reaction to this report resulted in multilateral efforts to track hospital outcomes and ultimately improve the quality of healthcare delivery in the USA. 'Failure to rescue' (FTR) is a measure of hospital quality and safety [2] derived from this work and is defined as mortality attributable to preventable/identifiable complication(s). FTR describes the ability of a provider or institution to recognise key complications and intervene before death [3,4]. Whilst the comparison of overall complication and mortality rates penalise institutions treating more complex and sicker patients, FTR rates may be a more accurate measure of safety and quality of care [3,4].

Several authors have recently examined national trends in surgical outcomes, reporting a consistent decline in inpatient mortality [5,6]. In particular, Semel et al. [7] reported significant declines in adjusted mortality for many high-risk cardiovascular and oncological surgeries between 1996 and 2006. The authors showed that the decrease in mortality was largely attributable to a decline in FTR rates. Subsequently, numerous studies have examined mortality and FTR rates in specific high-risk urological procedures [8–10]; however, there has been no assessment of overall and FTR mortality in patients undergoing the breadth of urological surgery in the USA, including commonly performed non-oncological procedures. Given procedural trends and favourable FTR rates in the general surgery literature, we hypothesised that urological procedure volumes would have increased over the study period, with a concomitant decrease in overall and FTR mortality.

Patients and Methods

Admission data on all patients undergoing a urological surgery between 1 January 1998 and 31 December 2010 were extracted from the Nationwide Inpatient Sample (NIS) [11] and assessed for inpatient mortality. The NIS is a set of longitudinal hospital inpatient databases included in the Healthcare Cost and Utilization Project [11] family, created by the Agency for Healthcare Research and Quality through a Federal–State partnership. Data are ascertained by a 20% stratified probability sample of non-Federal USA hospitals. Sampling probabilities are proportional to the number of hospitals in each stratum, based on five hospital characteristics: ownership and profit status, number of beds, teaching status, urban/rural location, and region. Post-stratification discharge weights are then used to calculate national estimates.

The database includes discharge abstracts from 8 million hospital stays annually and is the sole hospital database in the USA with charge information on all patients regardless of payer, including persons covered by Medicare, Medicaid, private insurance, and the uninsured. Each discharge includes up to 15 inpatient diagnostic and 15 procedural codes. All procedures and diagnoses are coded using the International Classification of Diseases, 9th revision, Clinical Modification (ICD–9–CM).

Study Population

Relying on discharge records, 1 567 743 unique hospitalisations for patients undergoing urological surgery were identified; sampling weights were applied to provide national estimates (n = 7 725 736) after excluding patients for missing demographic/hospital data.

Procedures are included in the NIS regardless of whether they are surgical in nature. To differentiate surgical procedures, we relied on a data extraction methodology developed by Semel et al. [7]. To summarise, five surgeon reviewers independently classified ICD-9-CM procedure codes as either surgical or non-surgical. A surgical procedure was defined to include all operating room and non-operating room procedures involving incision, excision, manipulation, or suturing of tissue, and usually requiring regional or general anaesthesia or profound sedation to control pain [12]. To achieve consensus, an ICD-9-CM code was included or excluded when at least four reviewers agreed on its classification. ICD-9-CM codes for which at least two reviewers disagreed were discussed among the five reviewers until at least four agreed on its classification. This resulted in the identification of 2520 unique surgical procedures. From this list, urological procedures were identified based on the consensus of a panel of three urologists. Procedures performed by urologists and non-urologists (i.e. adrenalectomy and kidney transplant) were included in the analysis. A sensitivity analysis was performed, excluding patients undergoing transplantation (n = 200 288), without substantively affecting key study endpoints; subsequently these patients were left in the study population. Newborn circumcision was excluded due to the number performed, paucity of associated morbidity and performance by non-urologists. Only patients with a primary procedural code corresponding to one of the identified urological procedures were included in the study cohort.

Patient and Hospital Characteristics

Patient variables assessed included: age, race (White, Black, Hispanic, Other or Unspecified) insurance status as well Charlson Comorbidity Index (CCI). Baseline CCI was calculated according to Charlson et al. [13], as adapted by Deyo et al. [14]. Insurance categories are combined in general groups, namely private insurance, Medicare, Medicaid, and other (self-pay). Hospital characteristics include hospital region (Northeast, Midwest, South, West), which were obtained from the American Hospital Association Annual Survey of Hospitals, and defined by the United States Census Bureau [15], as well as location (rural vs urban) and teaching status [11].

Endpoints

The primary endpoints were overall mortality, FTR mortality and the proportion of mortality attributable to FTR. Specifically, FTR mortality was defined as in-hospital mortality after a complication that was potentially recognisable/preventable including sepsis, pneumonia, deep venous thrombosis or pulmonary embolism, shock or cardiac arrest, or upper gastrointestinal bleeding during an admission with a surgical procedure. FTR was established according to a coding algorithm described by Silber et al. [16] and Needleman et al. [17], relying on ICD-9-CM codes, diagnosis-related groups, and major diagnostic categories to identify patients with a preventable adverse event (Table A1). These rules have subsequently been adapted by the Agency for Healthcare Research and Quality as part of Patient Safety Indicators to measure FTR rates among surgical inpatients. The rules have explicit inclusion and exclusion criteria to reduce misclassification of comorbidities as complications.

Deaths in patients with other complications or those meeting exclusion criteria were considered 'other cause' mortality. Due to the heterogeneity of surgical procedures included, robust exclusion criteria must be pursued, for example a patient with sepsis due to an obstructing ureteric calculus who undergoes ureteric stenting and subsequently dies would not be considered FTR if sepsis was the admission diagnosis. The annual rate of preventable adverse events and FTR were examined, as well as the proportion and predictors of FTR within all inpatient mortality. Analyses were performed for the entire patient cohort, the 10 most common surgeries and the 10 surgeries that contributed most to urological surgical mortality.

Statistical Analyses

Descriptive statistics were used to compare baseline characteristics. Medians and interquartile ranges were reported for continuously coded variables, and compared with the Wilcoxon rank-sum test. Proportions were reported for categorical values and were compared with chi-square and Fischer's exact tests. Temporal trends in admissions, mortality and FTR were analysed using the estimated annual percentage change (EAPC) linear regression methodology, as previously described [18]. The R package geepack, which implements the generalised estimating equations (GEE) approach for fitting marginal generalised linear models to clustered data, was used to construct a logistic regression model to evaluate hospital and patient characteristics independently associated with mortality and FTR mortality, as well as the independent effect of increasing year on overall and FTR mortality for all procedures and the 10 most common procedures [19]. Covariates included age, race, gender, CCI, insurance category, year, admission type, as well as hospital location, region, teaching status and volume.

All statistical analyses were performed using the R statistical package (R Foundation for Statistical Computing, Vienna, Austria), with a two-sided significance level set at $P < 0.003$ to account for multiple comparisons. An Institutional Review Board waiver was obtained before conducting this study, in accordance with institutional regulation when dealing with de-identified administrative data.

Results

Between 1998 and 2010, an estimated 7 725 736 urological surgeries requiring hospitalisation were performed in the USA. Baseline characteristics of the entire cohort were stratified according to overall mortality and FTR mortality, patient and hospital descriptors varied significantly (Table 1). Relative to Caucasian patients, Black patients (6.9% of the total population) were at a higher risk of in-hospital mortality, representing 10.4% of those who died and 10.7% of those with an FTR event ($P < 0.001$). Patients with CCI of ≥3 comprised 3.3% of total the population, 12.3% of those who died and 14.2% of those with an FTR event ($P < 0.001$). Urgent admission was associated with both overall and FTR mortality; patients admitted urgently made up 37.5% of the total population, 70.6% of those who died and 68.7% of those who with an FTR event ($P < 0.001$). Patients admitted to high-volume (tertile) hospitals represented 33.5% of the overall population, but composed only 33.1% and 30.9% of the overall mortality and FTR populations, respectively ($P < 0.001$; Table 1).

Over this period, the number of annual admissions for urological surgery decreased from 605 629 in 1998 to 569 784 in 2010, (EAPC: −0.63%, 95% CI −1.05 to −0.21)). Of these, 54 949 (0.71%) were associated with in-hospital mortality (EAPC: −0.14%, 95% CI −0.68 to 0.54) (Fig. 1). After adjustment for patient and hospital characteristics, odds of overall mortality fell 1% per year over the study period (odds ratio [OR] 0.99, 95% CI 0.99–0.99). Decreases in mortality were seen in several common urological surgeries as well as common contributors to urological mortality including: TURP, radical prostatectomy (RP), ureteric stenting, transurethral resection of bladder tumour (TURBT), percutaneous nephrostomy (PCN) placement, retrograde pyelogram, bladder biopsy and percutaneous cystostomy placement (Tables A2 and A3).

In multivariable analyses of patients with in-hospital mortality (Table 2), patient age (OR 1.041), Black race vs Caucasian (OR 1.504), CCI of 2 vs 0 (OR 1.187) and ≥3 vs 0 (OR 3.271), Medicaid vs Private (OR 2.468) and Medicare vs Private (OR 1.761) insurance status, as well as urban hospital location vs rural (OR 1.349) were independent predictors of FTR mortality (all $P < 0.001$). Additional predictors of FTR mortality included urgent vs non-urgent admission (OR 3.478, $P < 0.001$) and hospital teaching status (OR 1.357, $P < 0.001$).

The proportion of mortality attributable to preventable adverse events increased markedly over the study period, from 41.1% in 1998 to 59.5% in 2010 (EAPC: +2.94%, 95% CI 1.87–4.02) (Fig. 2). After adjustment, the odds of FTR mortality increased by 5.0% per year (OR 1.050, 95%CI 1.038–1.062). These trends were recorded for several procedures including TURP, ureteric stenting, nephrectomy, TURBT, PCN placement, bladder biopsy and cystectomy (Tables A2 and A3)

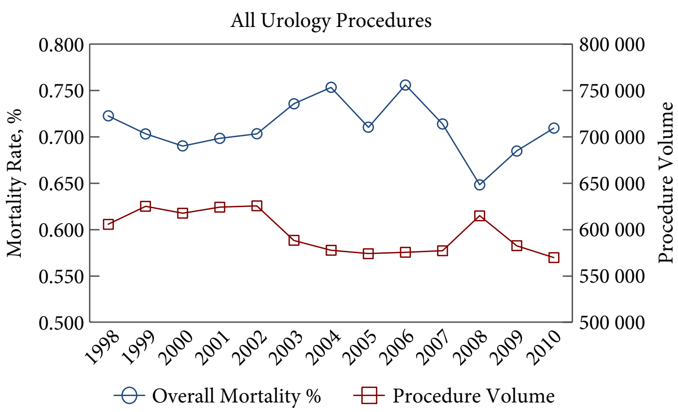
The most pronounced changes in inpatient admissions were seen for TURP, which decreased from 119 915 admissions in 1998 to 49 829 admissions in 2010 (EAPC −5.58%, 95% CI −6.32 to −4.85; $P < 0.001$). Adjusted odds of mortality decreased over the study period (OR 0.94, 95% CI 0.91–0.97), whereas FTR mortality increased significantly (OR 1.06, 95% CI 1.01–1.10) (unadjusted EAPC: 0.12%, 95% CI 0.06–0.19, $P = 0.004$) (Fig. 2, Table A2).

Table 1 Weighted descriptive characteristics of patients undergoing urological procedures. NIS 1998–2010. The overall mortality population and FTR population differed significantly from the total population and from each other; for all comparisons $P < 0.001$.

	Total	Overall mortality*	FTR mortality
Weighted number of patients	7 725 736	54 949	25 636
Median (IQR) age, years	62 (49–73)	75 (62–82)	75 (64–82)
%:			
Gender:			
Male	63.3	65.2	66.0
Female	36.7	34.8	34.0
Race:			
Caucasian	60.1	58.2	59.1
Black	6.9	10.4	10.7
Hispanic	6.5	5.4	5.4
Other	3.7	4.0	4.6
Unknown	22.9	21.9	20.2
CCI:			
0	70.2	54.8	54.1
1	20.9	23.9	23.5
2	5.6	9.0	8.2
≥3	3.3	12.3	14.2
Visit type:			
Not urgent	62.5	29.4	31.3
Urgent	37.5	70.6	68.7
Insurance status:			
Private	41.6	17.2	15.5
Medicaid	6.6	6.4	6.7
Medicare	45.5	71.2	74.3
Self-Pay/Other	6.4	5.2	3.5
Hospital location:			
Rural	12.0	10.3	9.3
Urban	88.0	89.7	90.7
Hospital region:			
Northeast	21.1	24.0	24.6
Midwest	23.7	21.6	20.5
South	36.2	37.0	36.5
West	19.0	17.4	18.4
Teaching status:			
Non-teaching	49.0	46.8	46.8
Teaching	51.0	53.2	53.2
Hospital volume:			
Low	33.1	35.2	34.5
Intermediate	33.4	33.7	34.6
High	33.5	33.1	30.9

*IQR, interquartile range. *Overall mortality includes FTR mortality and 'other cause' mortality.*

Fig. 1 The annual number of admissions for urological surgery decreased from 605 629 to 569 784 (EAPC: –0.63%, 95% CI –1.05 to –0.21). Of these, 54 949 (0.71%) were associated with in-hospital mortality (EAPC: –0.14%, 95% CI –0.68 to 0.54). NIS, 1998–2010.



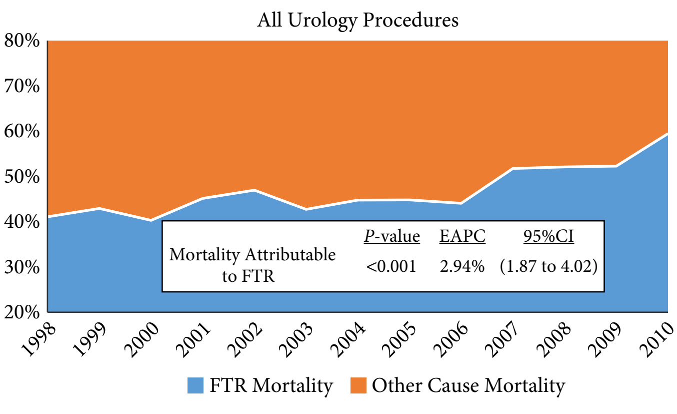
Discussion

Over the last two decades, measures to improve healthcare safety and quality have expanded significantly. In the context of surgical procedures, this has resulted in a decrease in overall and FTR mortality despite an increase in the number of inpatient admissions after surgery [7]. On the basis of these findings, we anticipated similar observations in Urology. Whilst FTR mortality has been assessed for selected high-risk urological procedures [8–10], it has not been evaluated for many commonly performed urological surgeries and has not been assessed in a longitudinal fashion. As such, we sought to examine the trends in surgical volume, in-hospital mortality, and specifically FTR mortality for common urological procedures performed in the USA between 1998 and 2010.

Table 2 Logistic regression of independent predictors of FTR amongst those inpatients who died after a urological procedure, fitted with GEE to account for hospital clustering. NIS 1998–2010.

	Overall mortality		FTR mortality		Odds of death being due to FTR	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Age	1.039 (1.038–1.04)	<0.001	1.041 (1.04–1.043)	<0.001	1.004 (1.001–1.007)	<0.001
Year	0.989 (0.987–0.992)	<0.001	1.015 (1.012–1.019)	<0.001	1.050 (1.038–1.062)	<0.001
Gender:						
Male	***		***		***	
Female	1.067 (1.048–1.086)	<0.001	1.037 (1.01–1.065)	0.007	0.931 (0.898–0.965)	<0.001
Race:						
Caucasian	***		***		***	
Black	1.457 (1.415–1.5)	<0.001	1.504 (1.443–1.569)	<0.001	1.091 (1.029–1.157)	0.225
Hispanic	0.951 (0.915–0.989)	0.102	0.957 (0.904–1.013)	0.127	0.988 (0.914–1.069)	0.766
Other	1.174 (1.123–1.228)	<0.001	1.309 (1.231–1.391)	<0.001	1.258 (1.151–1.376)	0.013
Unknown	1.118 (1.092–1.144)	<0.001	1.057 (1.021–1.094)	0.002	0.92 (0.879–0.964)	0.075
CCI:						
0	***		***		***	
1	1.045 (1.023–1.067)	<0.001	1.003 (0.973–1.034)	0.836	0.934 (0.896–0.975)	0.002
2	1.344 (1.304–1.386)	<0.001	1.187 (1.133–1.243)	<0.001	0.837 (0.787–0.89)	<0.001
≥3r	2.916 (2.837–2.996)	<0.001	3.271 (3.15–3.396)	<0.001	1.354 (1.283–1.429)	<0.001
Visit type:						
Not urgent	***		***		***	
Urgent	3.909 (3.835–3.984)	<0.001	3.478 (3.385–3.575)	<0.001	0.835 (0.804–0.867)	<0.001
Insurance status:						
Private	***		***		***	
Medicaid	2.143 (2.059–2.23)	<0.001	2.468 (2.328–2.616)	<0.001	1.329 (1.226–1.439)	0.003
Medicare	1.591 (1.55–1.634)	<0.001	1.761 (1.692–1.833)	<0.001	1.262 (1.199–1.329)	<0.001
Self-Pay/Other	1.759 (1.686–1.835)	<0.001	1.316 (1.224–1.416)	<0.001	0.647 (0.591–0.708)	<0.001
Hospital location:						
Rural	***		***		***	
Urban	1.256 (1.219–1.294)	<0.001	1.349 (1.288–1.411)	<0.001	1.172 (1.103–1.245)	0.042
Hospital region:						
Northeast	***		***		***	
Midwest	0.848 (0.826–0.871)	<0.001	0.816 (0.785–0.849)	<0.001	0.92 (0.871–0.971)	0.282
South	1.026 (1.003–1.05)	0.028	1.013 (0.98–1.047)	0.445	0.962 (0.919–1.007)	0.664
West	1.186 (1.154–1.219)	<0.001	1.206 (1.159–1.254)	<0.001	1.036 (0.98–1.095)	0.370
Teaching status:						
Non-teaching	***		***		***	
Teaching	1.372 (1.345–1.401)	<0.001	1.357 (1.317–1.398)	<0.001	1.001 (0.96–1.044)	0.973
Hospital volume:						
Low	***		***		***	
Intermediate	0.958 (0.938–0.979)	<0.001	0.992 (0.961–1.023)	0.599	1.081 (1.035–1.129)	0.151
High	0.96 (0.937–0.985)	0.001	0.96 (0.926–0.995)	0.028	1.032 (0.982–1.086)	0.566

Fig. 2 The proportion of mortality attributable to preventable adverse events increased markedly over the study period, from 41.1% in 1998 to 59.5% in 2010 (EAPC: 2.94%, 95% CI 1.87–4.02). NIS, 1998–2010.



Several of our present study findings are novel and merit further consideration. First, we recorded a decrease in the annual number of inpatient urological surgeries performed in the USA between 1998 and 2010 from 605 629 to 569 784 (EAPC: −0.63%, 95% CI −1.05 to −0.21). These findings contrast with previously reported temporal trends for surgical procedures in general [7] and also for several urological oncology procedures [20–22]. Over the study period, the top 10 most commonly performed surgeries accounted for 66.72% of all inpatient urological procedures, with TURP accounting for 14.78% overall. The annual number of inpatient admissions for TURP declined dramatically from 119 915 in 1998 to 49 829 in 2010 (EAPC: −5.58%). The dramatic decrease in hospital admissions for TURP is likely due to a shift toward outpatient/office procedures for the management of BPH [23]. This shift toward ambulatory procedures may also be contributing to an increase in the average acuity of inpatients.

Despite numerous Federal, regional, State and industry-sponsored safety initiatives, in-hospital mortality after urological surgery decreased only slightly between 1998 and 2010, and FTR mortality increased over this period. Furthermore, among patients with in-hospital mortality, there was a substantial increase in the proportion of deaths attributable to FTR. Given that our population includes only inpatient admissions after any urological surgery, the shift in admission practices may have had a significant effect on the observed trends, as more complex procedures or patients are managed in the inpatient setting [23]. Nonetheless, these findings also raise the possibility that the care of urological surgical patients is suffering from inadequate or poorly applied patient safety measures. It is worrisome that the odds of FTR associated mortality have increased over time for TURP, ureteric stenting, nephrectomy, TURBT, PCN placement, bladder biopsy and cystectomy (Tables A2 and A3).

While the concept of FTR implies a shortcoming of the system rather than the individual, it does raise concerns about the timely recognition and proper management of complications after surgery. Such deficiencies may be amplified as residency training is shortened and further restrictions are applied with regard to continuity of care during residency [24]. In a similar study, Sukumar et al. [25] also used the NIS to evaluate hospital-acquired preventable adverse events for eight major cancer surgeries (including radical cystectomy and RP), and found that despite an increase in the frequency of adverse events, there was a decrease in FTR and overall mortality. Unfortunately, the overall and FTR mortality for the individual surgeries included within their work are not disclosed, and thus direct comparison to the present work is not possible. Nonetheless, our present findings for RP and radical cystectomy mirror their overall findings of decreased overall and FTR mortality (Tables A2 and A3). It is probable that the conflicting findings of the present study are attributable to case mix and perhaps to the low mortality rate of urological surgery in general, thus highlighting even small shifts in mortality. For example, we found that the overall rate of mortality for urological surgeries during the course of the present study was 0.71%; by comparison, Semel et al. [7] found a 1.32% rate of death for inpatient surgical procedures in 2006. Additionally, while not the primary study objective, it is important to note that our present results confirm the declining trend in RP perioperative mortality. Perioperative risk has recently been cited by the USA Preventive Services Task Force (USPSTF) as part of the rationale against routine PSA screening [26].

Multivariable modelling of those with inpatient mortality revealed several key predictors that increased the odds of FTR mortality. These included increasing age, race, Medicaid, Medicare, or self-pay insurance status, CCI and treatment at an urban hospital. Previous investigators have reported increased FTR mortality rates in similar subgroups. For example, Trinh et al. [10] identified age, comorbidities, and insurance status as independent predictors of FTR after radical cystectomy. Amongst trauma patients, the uninsured are more likely to experience FTR mortality than those with private insurance [27]. Taken together, our present findings suggest that older and/or sicker patients are most likely to succumb from FTR and warrant increased attention when they experience a complication, while system attributes such as insurance and hospital location may affect the quality of care in patients undergoing urological surgery.

From a practical standpoint, the results of the present study have major implications for the urological community. Our present findings provide evidence of a major shift in the type of patients being admitted for urological surgery. Historically, a much larger proportion of relatively healthy urology patients were admitted for low-risk procedures, e.g. TURP. As the management of such conditions has shifted towards ambulatory care, the inpatient population has become generally sicker. Over the study period the percentage of patients with CCI of zero fell from 73.7% to 65.3% (data not shown). Consequently, urological surgeons and ancillary staff members need to recognise that the contemporary cohort of urology inpatients is generally at higher risk of complications and consequently FTR mortality. A heightened awareness to early signs of complications may abrogate unfavourable outcomes.

This report of nationwide urological surgical mortality must be interpreted within the limitations of its study design. The validity of any study conducted with an administrative data set relies heavily on the accuracy of coding that was initially performed for the purpose of billing. The coding of complications may be variable, and therefore it is feasible that the recorded increase in FTR mortality is a corollary of changes in coding practices. Conversely, mortality is highly accurate within administrative datasets, as it is less subjective by definition [28]. Additionally, multiple definitions of FTR exist, each of these definitions have different rates of positive predictive value and sensitivity, making comparison between studies difficult [29]. A further limitation of the present study, and all studies reporting data from the NIS, is that data are not linked across admissions. For instance, if a patient is discharged postoperatively, is subsequently readmitted and then dies, this patient's death is not captured in this study. Therefore, it is possible that discharge before the onset of complication or mortality could skew mortality within this study. Additionally, the NIS does not capture several key patient characteristics, such as smoking status and body mass index, which are known predictions of postoperative complications and thus we could not perfectly adjust for these covariates. Despite these limitations, the results of the present analysis are novel and noteworthy, and will help urologists better understand trends within the specialty. Additionally, our work highlights FTR mortality as an area requiring further attention, especially for older, sicker and minority group patients.

Between 1998 and 2010 the number of patients undergoing inpatient urological surgery has fallen. While overall risk of mortality has fallen the risk of FTR has increased, possibly as a result of a higher risk inpatient population. Furthermore, older, sicker, minority group patients and those with public insurance were more likely to die after a potentially recognisable/preventable complication. These strata of high-risk individuals represent ideal targets for process improvement initiatives.

Conflicts of Interest

A.S.K. consults on Advisory Boards for Sanofi-Aventis, Dendreon and Myriad.

All other authors have nothing to disclose.

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Abbreviations: CCI, Charlson Comorbidity Index; EAPC, estimated annual percentage change; FTR, failure to rescue; GEE, generalised estimating equations; ICD–9–CM, International Classification of Diseases, 9th revision, Clinical Modification; NIS, Nationwide Inpatient Sample; OR, odds ratio; PCN, percutaneous nephrostomy; RP, radical prostatectomy; TURBT, transurethral resection of bladder tumour.

Appendix

Table A1 Coding rules for FTR*.

Outcome	Definition	
Hospital-acquired pneumonia	Included: ICD-9-CM: 507.0, 997.3, 514, 482.0–482.2, 482.4–482.9, 485, 486	Excluded: Primary diagnosis – ICD-9-CM: 480–487, 507.0, 514, 997.3; secondary diagnosis – ICD-9-CM: 480, 481, 483, 484, 487; MDC 4, AIDS,† immunocompromised states†
Shock or cardiac arrest	ICD-9-CM: diagnoses – 427.5, 785.5, 785.50, 785.51, 785.59, 799.1; procedures – 93.93, 99.6, 99.63	Primary diagnosis, MDC 4, MDC 5, haemorrhage,† trauma†
Upper gastrointestinal bleeding	ICD-9-CM: 531.00–531.31, 531.9, 532.00–532.31, 532.9, 533.00–533.31, 533.9, 534.00–534.31, 534.9, 535.01, 535.4, 578.9, 530.82	Primary diagnosis, MDC 6–7, trauma,† burn,† alcoholism,† ICD-9-CM: 280.0, 285.1
Hospital-acquired sepsis	ICD-9-CM: 038, 790.7	Primary diagnosis, immunocompromised states,† AIDS,† length of stay <3 days, DRG: 20, 68–70, 79–81, 89–91, 126, 238, 242, 277–279, 320–322, 415–417, 423
Deep venous thrombosis	ICD-9-CM: 415.1, 415.11, 451.11, 451.19, 451.2, 451.81, 453.8	Primary diagnosis, ICD-9-CM: 673.2
Death	Discharge status – death	None
FTR	Discharge status – death, with sepsis, pneumonia, upper gastrointestinal bleeding, shock or cardiac arrest, or deep venous thrombosis	Absence of sepsis, pneumonia, upper gastrointestinal bleeding, shock or cardiac arrest, or deep venous thrombosis

**ICD-9-CM denotes International Classification of Diseases, 9th Revision, Clinical Modification; MDC major diagnostic category; AIDS acquired immunodeficiency syndrome; DRG diagnosis-related group. FTR was established according to a coding algorithm described by Silber et al. [16] and Needleman et al. [17]. †The condition was as defined in Iezzoni [30] . updated to match the 1997 codes.*

Table A2 The independent effect of advancing year on any cause mortality and FTR mortality after the most common urological surgeries; adjusted for age, race, gender, CCI, insurance status, admission type and hospital region, teaching status and urban/rural location. NIS, 1998–2010.

Procedure	ICD-9	Overall volume	% of volume	Any cause mortality rate		FTR mortality rate		FTR as % of mortality*	
				Unadjusted rate, %	Effect of year OR (95% CI)	Unadjusted rate, %	Effect of year OR (95% CI)	Unadjusted rate, %	Effect of year OR (95% CI)
Overall	–	7 725 736	–	0.71	0.990 (0.988–0.993)	0.33	1.015 (1.012–1.019)	46.65	1.050 (1.038–1.062)
TURP	60.29	1 144 091	14.78	0.31	0.943 (0.914–0.974)	0.15	1.002 (0.988–1.015)	47.40	1.060 (1.013–1.109)
RP	60.5	850 069	10.98	0.07	0.885 (0.839–0.933)	0.05	0.88 (0.858–0.907)	63.40	0.971 (0.864–1.092)
Ureteric catheterisation / stent placement	59.8	632 365	8.17	0.83	0.954 (0.938–0.970)	0.33	0.973 (0.962–0.985)	40.02	1.038 (1.001–1.078)
Ureteroscopy	56.0	586 111	7.57	0.20	1.023 (0.986–1.061)	0.11	1.030 (1.008–1.052)	55.62	1.045 (0.969–1.127)
Nephrectomy / nephroureterectomy	55.51	562 397	7.26	1.15	0.994 (0.975–1.014)	0.47	1.016 (1.005–1.026)	40.97	1.049 (1.010–1.090)
TURBT	57.49	451 899	5.84	1.22	0.980 (0.964–0.996)	0.49	1.006 (0.995–1.017)	40.99	1.055 (1.018–1.094)
PCN without stone extraction	55.03	290 361	3.75	3.51	0.984 (0.971–0.998)	1.68	1.012 (1.004–1.020)	49.46	1.052 (1.027–1.078)
Repair of urinary stress incontinence	59.79	232 529	3.00	0.02	***	0.02	***	67.80	***
Cystocele / rectocele repair	70.50	210 296	2.72	0.03	***	0.02	***	64.18	***
Retrograde pyelogram	87.74	205, 405	2.65	0.75	0.943 (0.914–0.974)	0.27	0.963 (0.940–0.986)	36.31	1.035 (0.966–1.110)

**Odds of FTR mortality vs other cause mortality calculated within the population of patients who died; ***event frequency too low to model.*

Table A3 The independent effect of advancing year on any cause mortality and FTR mortality after the most significant contributors to urological surgical mortality; adjusted for age, race, gender, CCI, insurance status, admission type and hospital region, teaching status and urban/rural location. NIS, 1998–2010.

Procedure	ICD-9	Overall Volume	% of mortality	Any cause mortality		FTR Mortality Rate		FTR as % of mortality*	
				Unadjusted rate, %	Effect of year OR (95% CI)	Unadjusted rate, %	Effect of year OR (95% CI)	Unadjusted rate, %	Effect of year OR (95% CI)
Overall	–	7 725 736	–	0.71	0.990 (0.988–0.993)	0.33	1.015 (1.012–1.019)	46.65	1.050 (1.038–1.062)
PCN without stone extraction	55.03	290 361	17.90	3.51	0.984 (0.971–0.998)	1.68	1.012 (1.004–1.020)	49.46	1.052 (1.027–1.078)
Nephrectomy / nephroureterectomy	55.51	562 397	11.60	1.15	0.994 (0.975–1.014)	0.47	1.016 (1.005–1.026)	40.97	1.049 (1.010–1.090)
TURBT	57.49	451 899	9.88	1.22	0.980 (0.964–0.996)	0.49	1.006 (0.995–1.017)	40.99	1.055 (1.018–1.094)
Ureteric catheterisation / stent placement	59.8	632 365	9.45	0.83	0.954 (0.938–0.970)	0.33	0.973 (0.962–0.985)	40.02	1.038 (1.001–1.078)
TURP	60.29	1 144 091	6.39	0.31	0.943 (0.914–0.974)	0.15	1.002 (0.988–1.015)	47.40	1.060 (1.013–1.109)
Radical cystectomy	57.71	101 342	4.14	2.30	0.990 (0.996–1.014)	1.39	1.063 (1.024–1.055)	61.05	1.12 (1.065–1.185)
Retrograde pyelogram	87.74	205 405	2.77	0.75	0.943 (0.914–0.974)	0.27	0.963 (0.940–0.986)	36.31	1.035 (0.966–1.110)
Open suprapubic cystostomy	57.18	66 257	2.70	2.29	1.011 (0.979–1.045)	1.15	1.002 (0.982–1.022)	50.67	0.992 (0.928–1.062)
Bladder biopsy	57.33	79 862	2.64	1.85	0.966 (0.935–0.999)	0.73	1.007 (1.000–1.014)	39.92	1.073 (1.000–1.151)
Percutaneous cystostomy	57.17	30 081	2.50	4.78	0.930 (0.900–0.961)	1.75	0.948 (0.926–0.971)	37.65	1.026 (0.958–1.099)

**Odds of FTR mortality vs other cause mortality calculated within the population of patients who died.*

Table A4 Patient safety indicator (PSI) and mortality event rates for patients undergoing urological surgery. NIS, 1998–2010.

Year	Sepsis, %	HAP, %	GI bleed %	Shock/cardiac arrest %	DVT %	Any PSI %	Mortality %
1998	0.911	1.7451	0.4207	0.2001	0.5091	3.558	0.723
1999	0.9385	1.9486	0.4004	0.1812	0.49	3.6695	0.703
2000	0.9748	1.743	0.3414	0.2174	0.5299	3.5201	0.690
2001	1.0638	1.7941	0.3626	0.2666	0.5112	3.6766	0.698
2002	1.2244	1.8829	0.378	0.2936	0.5746	3.9744	0.703
2003	1.2537	2.081	0.3893	0.2661	0.6528	4.2527	0.736
2004	1.493	2.1816	0.4009	0.1258	0.6394	4.4305	0.754
2005	1.4607	2.223	0.3976	0.1059	0.4194	4.2269	0.710
2006	1.6512	2.2686	0.4108	0.119	0.4346	4.4593	0.756
2007	1.7363	2.2824	0.4692	0.166	0.4623	4.61	0.714
2008	1.5274	2.4031	0.5873	0.2238	0.4775	4.7165	0.648
2009	1.6389	2.5647	0.5171	0.2365	0.4958	4.9062	0.685
2010	1.8688	2.6271	0.4661	0.3005	0.5225	5.1314	0.709
EAPC	8.78	4.24	1.86	4.90	–0.79	3.74	–0.14
95% CI	7.28 to 10.29	3.45 to 5.03	0.99 to 4.72	–4.40 to 5.40	–2.71 to 1.14	3.24 to 4.23	–0.68 to 0.54
P	<0.001	<0.001	0.007	0.921	0.419	<0.001	0.605

HAP, hospital-acquired pneumonia; GI, gastrointestinal; DVT, deep venous thrombosis.

