Variations in the quality of care at radical prostatectomy

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Abstract: Postoperative morbidity and mortality is low following radical prostatectomy (RP), though not inconsequential. Due to the natural history of the disease process, the implications of treatment on long-term oncologic control and functional outcomes are of increased significance. Structures, processes and outcomes are the three main determinants of quality of RP care and provide the framework for this review. Structures affecting quality of care include hospital and surgeon volume, hospital teaching status and patient insurance type. Process determinants of RP care have been poorly studied, by and large, but there is a developing trend toward the performance of randomized trials to assess the merits of evolving RP techniques. Finally, the direct study of RP outcomes has been particularly controversial and includes the development of quality of life measurement tools, combined outcomes measures, and the use of utilities to measure operative success based on individual patient priority.

Keywords: hospital volume, prostatectomy, prostatic neoplasms, quality of care, surgeon volume

Introduction

In 2010, 217,730 men were diagnosed with prostate cancer within the United States, accounting for 28% of all newly diagnosed cancers in men [Jemal *et al.* 2010]. An estimated 92% of these new cases are diagnosed at local or regional stages, for which the 5-year disease-specific survival approaches 100%. An important number of these patients will undergo radical prostatectomy (RP), a standard of care option for definitive treatment of prostate cancer. Large population-based series have demonstrated that postoperative morbidity and mortality after RP is relatively low, albeit not inconsequential [Begg *et al.* 2002; Ellison *et al.* 2000; Wennberg *et al.* 1987; Yao and Lu-Yao, 1999]. These reports have shown that these outcomes vary considerably according to several patient and system attributes, including patient comorbidities, surgeon volume, and hospital volume. Similar findings were reported with regard to equally important endpoints, such as oncological [Ellison *et al.* 2005] and functional [Hu *et al.* 2003] outcomes.

Based on the reported disparities in quality of care, policymakers, and healthcare management

organizations have established strategies to improve outcomes after surgery [Birkmeyer *et al.* 2001; Dudley *et al.* 2000; Miller *et al.* 2005]. For example, the Leapfrog Group for Patient Safety [Milstein *et al.* 2000] and the National Quality Forum have used hospital volume as a marker of quality for complex surgical procedures. The validity of such benchmarks has not been validated in the context of RP, yet regionalization and selective referral of urologic cancer care to high-volume urban centers have occurred over the past decade [Cooperberg *et al.* 2007].

In this review, we assess the current evidence on determinants of quality of care at RP. Specifically, we focus on the three main components of quality healthcare, namely structures, processes, and outcomes, and how each has been examined in the context of RP.

Conceptual framework

The critical analysis of surgical quality of care is usually performed within the conceptual framework of quality in healthcare proposed by Donabedian, which encompasses three main

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Figure 1. Conceptual model of relationships between structure, process of care, complications and mortality after surgery. ICU, intensive care unit. [Reproduced with permission from Birkmeyer and Dimick [2009].]

components: structures, processes, and outcomes [Birkmeyer *et al.* 2004; Donabedian, 1988]. These components are intrinsically intertwined, as shown in Figure 1. Structural components encompass the attributes of the setting in which care is given, the material resources and human resources, namely hospital and surgeon volume, subspecialty practice profile, and nurse staffing levels.

Good structure increases the likelihood of good process, which includes patient selection and evaluation, intraoperative and postoperative care, as well as the management of complications when they occur. Good process in turn increases the likelihood of good outcomes [Donabedian, 1988].

The preponderance of population-based studies assessing RP quality of care has focused on the effect of structural variables on outcomes, the primary advantage of studying structural variables being expediency [Birkmeyer *et al.* 2002, 2004]. Relative to direct outcomes assessment, structural variables can be assessed easily and inexpensively. To date, studies have been performed on the effect of surgeon and hospital volume, the effect of teaching institutions, as well as the effect of insurance status.

Whereas there is considerable evidence on the effect of specific processes of medical care on broad perioperative outcomes, such evidence is scant in the context of the technical aspects of RP. Significant data exist to support the use of venous thromboembolism prophylaxis, perioperative β -blockade for patients with high-risk cardiac conditions, and antibiotic wound prophylaxis [Shojania *et al.* 2001]. Actual improvements in processes of care specific to RP, however, are more often hypothesized than truly quantified.

An obvious area of great interest related to the process of care would be the comparative effectiveness of varied surgical techniques for RP and such evidence is in short supply and is usually of poor quality [Ficarra *et al.* 2009].

The third component of quality in healthcare analysis is outcomes measurement. Good structure and good process provide the framework to achieve good outcomes; however RP provides unique challenges to the study of outcomes. The indolent nature of the disease process, the low cancer-specific and overall mortality rate following treatment [Jemal *et al.* 2010] and the prevalence of morbidity associated with treatment have led to significant controversy in how best to measure outcomes. There has been great interest in the development of health-related quality of life (QoL) measurement tools, as well as combined outcomes measures and to a lesser degree utilities assessment.

Structural determinants of quality of care at radical prostatectomy

The most broadly studied structural determinants of surgical quality are hospital volume and type, surgeon volume, and more recently, insurance status.

Hospital volume

Access to care at high-volume institutions has been directly tied to decreased morbidity and mortality. In a landmark 2002 study, Birkmeyer and colleagues found that patients undergoing six different types of cardiovascular procedures and eight types of major cancer resections between 1994 and 1999 could significantly reduce their risk of operative death simply by receiving care

at a high-volume hospital [Birkmeyer *et al.* 2002]. The same investigators also demonstrated better cancer-specific survival rates were in patients treated at high-volume hospitals [Birkmeyer *et al.* 2007]. Similarly, Begg and colleagues demonstrated a significant reduction in operative mortality following major cancer procedures, namely pancreatectomy, esophagectomy, liver resection, and pelvic exenteration [Begg *et al.* 1998].

In the context of RP, increasing hospital volume is inversely associated with the risk of several important outcomes, including mortality [Alibhai *et al.* 2008; Ellison *et al.* 2000; Wennberg *et al.* 1987; Yao and Lu-Yao, 1999], prolonged length of stay [Ellison *et al.* 2000; Hanchanale and Javle, 2010; Hu *et al.* 2003; Trinh *et al.* 2011c; Yao and Lu-Yao, 1999], readmission [Yao and Lu-Yao, 1999] or adverse discharge disposition [Trinh *et al.* 2011a], intraoperative and postoperative [Alibhai *et al.* 2008; Begg *et al.* 2002; Hu *et al.* 2003; Trinh *et al.* 2011c; Yao and Lu-Yao, 1999] complications, urinary complications [Hu *et al.* 2003], transfusions [Trinh *et al.* 2011c] and the need for adjuvant therapy [Ellison *et al.* 2005] (Table 1). These findings rely on population-based datasets such as Medicare claims linked to SEER or the Nationwide Inpatient Sample (NIS). For example, Begg and colleagues examined the effect of hospital volume on outcomes of 11,522 men undergoing RP in the SEER-Medicare database [Begg *et al.* 2002]. Their study demonstrated that hospital volume did not independently predict surgery-related mortality. Conversely, hospital volume was inversely correlated with the risk of postoperative complications and late urinary complications. Interestingly, another study relying on the same dataset showed that patients treated at lower volume institutions are at increased risk of initiating adjuvant therapy with radiation, medical hormone ablation, or orchiectomy [Ellison *et al.* 2005]. Moreover, Ellison and colleagues examined the effect of hospital volume on outcomes of 66,693 men undergoing RP in the NIS database [Ellison *et al.* 2000]. The authors found that hospital volume was inversely related to in-hospital mortality, length of stay, and total hospital charges after RP. To summarize, substantial level II evidence has documented the importance of hospital volume for several short and long-term RP outcomes, encompassing perioperative safety, cancer-control, and functional outcomes.

It has been proposed that the mechanisms underlying the volume-outcomes relationship may not

be procedure specific. Hospitals that frequently deliver a range of complex surgical care may provide better care than institutions that specialize in a single surgical procedure. For example, Allareddy and Konety showed that hospitals meeting all five Leapfrog Volume Thresholds (≥ 450 coronary artery bypass grafts, ≥ 400 percutaneous coronary interventions, ≥ 50 abdominal aortic aneurysm repairs, ≥ 11 pancreatectomies, and ≥ 13 esophagectomies) were associated with lower odds for in-hospital mortality and lower odds for at least one complication following three of the five procedures [Allareddy and Konety, 2007]. Moreover, in a 2008 population-based analysis of the NIS, Gilbert and colleagues demonstrated that the volume-outcomes effect for index urologic oncology procedures is modified by experience with other nonindex specialty-related procedures [Gilbert *et al.* 2008]. Specifically, for RP, the magnitude of the volume-mortality association was reduced by 20% after adjusting for nonindex urologic oncology case volume. These findings suggest that transferable, effective processes of care could be identified within the subset of high-volume centers where better outcomes are recorded.

Surgeon volume

Several studies have focused on the impact of individual surgeon volume on outcomes (Table 2). Specifically, increasing surgeon volume is inversely associated with the risk of several important outcomes, including mortality, prolonged length of stay [Hu *et al.* 2003; Leibman *et al.* 1998; Litwiller *et al.* 1995], perioperative complications [Begg *et al.* 2002; Bianco *et al.* 2005a; Hu *et al.* 2003; Vesey *et al.* 2011], urinary complications [Begg *et al.* 2002; Bianco *et al.* 2005a; Vesey *et al.* 2011], transfusions [Dash *et al.* 2004; Litwiller *et al.* 1995], positive surgical margins [Chun *et al.* 2006; Eastham *et al.* 2003; Vesey *et al.* 2011], and cancer control [Jeldres *et al.* 2008; Vesey *et al.* 2011]. From a conceptual perspective, some outcomes are more likely to reflect hospital volume and concomitantly better organized perioperative care, while others would more likely be related to surgeon volume and skills [Wilt *et al.* 2008]. For example, Eastham and colleagues showed that lower rates of positive surgical margins are expected in high volume surgeons [Eastham *et al.* 2003].

Only two reports have assessed the impact of both surgeon and hospital volume within the same cohort of patients. Begg and colleagues, fitting

surgeon and hospital volume in separate models, showed that both variables were independent predictors of postoperative and late urinary complications [Begg *et al.* 2002]. However, only surgeon volume independently predicted the risk of long-term incontinence, suggesting that this outcome might be more dependent on surgical expertise. Similarly, Hu and colleagues reported that surgeon volume is inversely related to complications and length of stay in men undergoing RP [Hu *et al.* 2003]. Interestingly, in their analyses, hospital volume was not significantly associated with outcomes after adjusting for surgeon volume.

Teaching institutions

Several investigators have examined the role of institutional academic affiliation with regard to RP postoperative outcomes [Karakiewicz *et al.* 1998; Trinh *et al.* 2011c; Wennberg *et al.* 1987]. In an analysis of the Quebec Healthcare Plan Database, Karakiewicz and colleagues showed that 30-day mortality rate after RP was 0.45% at academic centers compared with 0.72% at nonacademic institutions [Karakiewicz *et al.* 1998]. Similarly, Trinh and colleagues found that even after adjusting for hospital volume, patients undergoing RP at academic institutions are less likely to experience intraoperative and postoperative complications, length of stay beyond the median, and blood transfusions [Trinh *et al.* 2011c].

There is likely a direct relationship between academic affiliation (structure) and processes that lead to higher quality of care, namely availability of technology, adherence to standardized clinical pathways, and sub-specialized training [Spencer *et al.* 2003]. Although never examined in the context of RP, the effect of teaching status on processes has been assessed for several medical conditions. Allison and colleagues showed that admission to a teaching hospital was associated with better quality of care based on three of four quality indicators, consisting of administration of aspirin during hospitalization, administration of angiotensin-converting enzyme inhibitors at discharge, and administration of β -blockers at discharge [Allison *et al.* 2000]. Keeler and colleagues demonstrated that academic institutions were associated with significantly better care based on explicit process measures (adherence to specified criteria), implicit reviews (subjective assessments of process by physicians), and outcomes (30- and 180-day mortality) [Keeler *et al.* 1992].

Insurance

Several reports have demonstrated a link between private insurance status and improved short-term adverse outcomes over a wide variety of surgical procedures and medical admissions, even after multivariable adjustment [Drolet *et al.* 2010; Hasan *et al.* 2010; McClelland *et al.* 2011]. LaPar and colleagues demonstrated that Medicaid insurance status was associated with the longest length of stay and highest total costs, while Medicaid and uninsured insurance status independently conferred the highest adjusted risks of mortality in patients undergoing major surgical operations [LaPar *et al.* 2010]. Similarly, Shen and Washington reported that uninsured patients had a higher level of neurologic impairment, a longer average length of hospital stay, and higher mortality risk following an acute ischemic stroke [Shen and Washington, 2007].

The effect of insurance status has recently been elucidated as a structural determinant of RP care [Trinh *et al.* 2011b]. When compared with patients with private insurance, Medicare and Medicaid patients are more likely to receive a blood transfusion, to experience a postoperative complication and to experience a prolonged hospitalization. Additionally, Medicaid patients are at a fivefold higher risk of in-hospital mortality following RP. The relationship between insurance status and clinical outcomes remains ill defined. The findings described in this study, as stated in many reports, likely result from a complex interaction between many processes affected by insurance status, most of which cannot be accounted for in the context of a population-based study.

Process determinants of quality of care at radical prostatectomy

Tremendous advances have been made in the general processes pertaining to perioperative medical management of all surgeries regardless of specialty. Level I evidence exists to support numerous clinical interventions, including appropriate use of prophylaxis to prevent venous thromboembolism; use of perioperative β -blockers when indicated; appropriate use of antibiotic prophylaxis; asking that patients recall and restate what they have been told during the informed consent process; appropriate provision of nutrition, with a particular emphasis on early enteral nutrition in critically ill and surgical patients [Shojania *et al.* 2001]. Evidence pertaining to the actual technique of performing RP is far less robust [Ficarra *et al.* 2009].

Surgical approach

In a 2009 review of comparative studies assessing outcomes following retropubic, laparoscopic, and robot-assisted radical prostatectomy Ficarra and colleagues found only 37 studies meeting inclusion criteria and a single randomized controlled trial (RCT) [Ficarra *et al.* 2009]. The key findings of this study were that laparoscopic RP and robot-assisted RP were more time consuming than open RP (particularly in the learning curve) but blood loss, transfusion rates, catheterization time, hospitalization duration, and complication rates all favored minimally invasive RP. A single nonrandomized study has demonstrated advantages of laparoscopic RP *versus* open RP regarding continence and potency but most studies demonstrate equivalence between surgical approaches in functional and oncologic outcomes. More recently, a study by Barocas and colleagues demonstrated equivalent early oncologic outcomes between open RP and robot-assisted RP with equivalent 3-year biochemical recurrence rates between groups when stratified by known risk factors of recurrence on multivariate analysis [Barocas *et al.* 2010].

Technical modifications

RCTs are rare within the urologic literature; nonetheless there is an appreciation of the need for trials to assess the benefits of evolving processes of care. In the years preceding this review, the pace of RCTs performed has quickened. Numerous aspects of RP have been submitted to randomization yielding results often at odds with prevailing wisdom or surgical trends. Authors have examined the effect of peri-anastomotic tissue (including the posterior musculofascial plate) reconstruction [Menon *et al.* 2008; Sammon *et al.* 2010; Sutherland *et al.* 2011], the impact of bladder neck mucosal eversion [Srougi *et al.* 2005], and the impact of anastomotic suture techniques using barbed suture [Sammon *et al.* 2011a; Williams *et al.* 2010]. While these trials are small, single institution analyses represent a trend towards greater scrutiny of processes of care and provide a level of evidence superior to retrospective case series.

Outcome selection and determining quality of care at radical prostatectomy

The quandary of assessing outcomes following RP is as old as the surgery itself. Patients undergoing RP (regardless of disease characteristics) have a protracted life expectancy following surgery

[Jemal *et al.* 2010] and bear a significant risk of functional deficit associated with treatment. As described by Donabedian, when outcomes are used to assess the quality of care, there is a need to characterize the states of dysfunction associated with treatment and to weigh them in importance relative to each other using some system of preferences [Donabedian, 1988].

The concept of 'Trifecta' has evolved within the RP outcomes literature to provide a combined system to evaluate the outcomes of surgery thought to be most important. This concept was first introduced in open RP by Salomon and colleagues in a study assigning a point system to the three most commonly scrutinized outcomes of RP, namely: recurrence-free survival (four points), continence (two points), and potency (one point) [Salomon *et al.* 2003]. This assumed a hierarchy of outcome importance based on the author's clinical experience and the collective wisdom of the broad urologic community. The application of the term 'Trifecta', however, was introduced later by Bianco and colleagues in 2005 to describe the combined reporting of oncologic control, continence, and potency [Bianco *et al.* 2005b].

The concept of Trifecta has many attractive attributes, primarily convenience for clinicians and researchers. It allows for a tidy presentation of the most important outcomes to the surgeon; it is however a flawed concept. Limitations of Trifecta analyses include varied definitions of the Trifecta elements biochemical recurrence (BCR), continence, and potency, binary responses to answers, and the lack of inclusion of preoperatively impotent men [Sammon *et al.* 2011b].

Quality of life assessment

The usage of validated QoL instruments in the evaluation of post-RP outcomes has gained broad support within the urologic community. The UCLA Prostate Cancer Index (PCI) [Litwin *et al.* 1998], validated in 1998, evaluates urinary, bowel, and sexual function domains. The 20-item UCLA-PCI was expanded to the 50-item Expanded Prostate Cancer Index Composite (EPIC), allowing for the assessment of urinary, sexual, bowel, and hormonal domains [Wei *et al.* 2000].

Several noteworthy multi-institutional longitudinal studies have used the EPIC or UCLA-PCI to

compare the commonest treatments of organ-confined prostate cancer [Malcolm *et al.* 2010; Pardo *et al.* 2010; Sanda *et al.* 2008]. The study by Sanda and colleagues was unique in that it also assessed the impact of QoL changes on patient or partner overall satisfaction with treatment outcome [Sanda *et al.* 2008]. In this study, they demonstrated that each type of prostate cancer treatment was associated with distinct changes in QoL domains. These changes impacted satisfaction with treatment among patients, as well as their partners.

Utilities

A fundamental limitation of combined outcomes reporting is that no preconceived notion of what the objectives and accomplishments of care should be will precisely fit any given patient. A reasonable approximation can be hoped for, but it must then be subject to individual adjustment [Donabedian, 1988]. To further this aim, investigators have attempted to gain insight into patient preferences through assessment of utility. A utility can be arrived at by several techniques, but is most commonly ascertained by time trade-off. In a time trade-off, a patient may choose between two health states: a longer lifespan in a disease state (such as metastatic prostate cancer, incontinence, erectile dysfunction) and a shorter life span in complete health [Albertsen *et al.* 1998; Saigal *et al.* 2001; Sommers *et al.* 2007, 2008; Stewart *et al.* 2005; Volk *et al.* 2004]. Saigal and colleagues determined that patients who had good baseline health valued quantity of life more, while those with poor general health prized quality of life more [Saigal *et al.* 2001]. Sommers and colleagues found, in a study of individual patient preferences, that 30% of patients had a different optimal treatment than the 'average' patient. Each patient must therefore have his priorities weighed individually rather than treating based on recommendations derived from populations [Sommers *et al.* 2007].

Improving quality of care: the case for and against regionalization

As volume and outcomes reporting is incorporated into healthcare policy, either explicitly or by means of radical reimbursement changes, care for complex surgeries such as RP may become regionalized. Although some would argue that

volume-based referral could improve quality of care and save lives for complex procedures [Dudley *et al.* 2000], it is likely that the American healthcare system is not designed or prepared for such measure. As such, Birkmeyer and colleagues [Birkmeyer *et al.* 2004] and Miller and colleagues [Miller *et al.* 2005] described a conceptual approach to improve quality of care based on procedure risk and volume [Cooperberg *et al.* 2009] (Figure 2).

For high-risk low-volume procedures such as esophagectomy [Finley *et al.* 2011] and pancreatectomy [McPhee *et al.* 2007], it is preferable to focus on structural measures, such as selective referral to high-quality hospitals and providers. For example, the volume–outcome relationship in cardiac surgery is deemed important enough that the New York State Department of Health publishes annual volume and mortality rates for every cardiac surgeon and interventional cardiologist. Yet, a study by Apolito and colleagues suggests that state-required reporting may result in the reluctance to revascularize patients with the highest-risk cardiac conditions [Apolito *et al.* 2008], thus highlighting the pitfalls of such an approach. Another example of large-scale initiative for volume-based referrals is the Leapfrog Group for Patient Safety, a coalition of corporations and agencies that buy health benefits on behalf of their enrollees, representing 34 million Americans and \$62 billion in healthcare expenditure [Birkmeyer *et al.* 2001]. Based on evidence supporting the volume–outcomes association, the Leapfrog Group established minimum hospital volume thresholds for five complex surgeries. This approach has been deemed polarizing ('winners' versus 'losers') in the for-profit setting of American healthcare and does not take into account the substantial variability in outcomes among hospitals that met Leapfrog volume criteria.

In contrast, for high-risk high-volume procedures such as RP, complete regionalization might be impossible [Cooperberg *et al.* 2007]. In these cases, procedure-specific processes should be reexamined, with the intent of reaching the levels recorded in patients with the best outcomes [Birkmeyer and Dimick, 2009]. Centralized outcomes measurement, modeled after the high standards set by bariatric surgeons [Birkmeyer *et al.* 2010], would be an ideal setting to ensure appropriate control of quality and process compliance. At the very least,

Figure 2. Conceptual approach to focusing quality improvement efforts based on procedure risk and volume. IVC, inferior vena cava; PCNL, percutaneous nephrolithotomy; RPLND, retroperitoneal lymph node dissection; TURBT, transurethral resection of bladder tumor; TURP, transurethral resection of prostate. (Reproduced with permission from Miller *et al.* [2005].)

systematic reporting of outcomes will likely trigger a ‘Hawthorne effect’, with subjects (surgeon, nursing and other personnel) improving simply in response to the fact that they are being studied and not in response to any specific manipulation.

Conclusions

Postoperative morbidity and mortality is low following RP, though not inconsequential. Due to the natural history of the disease process, the implications of treatment on long-term oncologic control and functional outcomes are of increased significance. Structures, processes, and outcomes

are the three main determinants of quality of RP care and provide the framework for this review. Structures affecting quality of care include hospital and surgeon volume, hospital teaching status, and patient insurance type. Process determinants of RP care have been poorly studied, by and large, but there is a developing trend toward the performance of trials to assess the merits of evolving RP techniques. Finally, the direct study of RP outcomes has been particularly controversial and includes the development of quality of life measurement tools, combined outcomes measures and the use of utilities to measure operative success based on individual patient priority.

Table 1. Studies examining the hospital volume–outcomes relationship after radical prostatectomy.

Authors	Study design	Sample size (n)/ participants	Country of origin	Dataset	Statistical adjustment	Hospital volume categories	Level of evidence	Statistically significant endpoints
[Wennberg <i>et al.</i> 1987]	Retrospective cohort	4570	United States	Medicare claims data	Age, CCI, hospital size, teaching status	<40, 40–90, ≥91/ year	2C	Surgery-related mortality
[Yao <i>et al.</i> 1999]	Retrospective cohort	101,604	United States	Medicare claims data	Age, race, comorbidities, surgeon specialty, teaching status	≤38, 39–74, 75–140, ≥141 within study period	2C	30- and 90-day mortality, major complications, length of stay, rehospitalization
[Ellison <i>et al.</i> 2000]	Retrospective cohort	66,693, 1334 hospitals	United States	Nationwide Inpatient Sample	Age, CCI	< 25, 25–54, >54/ year	2C	Mortality, length of stay, hospital charges
[Imperato <i>et al.</i> 2000]	Cross-sectional	583 New York Medicare, 113 hospitals	United States	Medicare claims data	–	1–4, 5–9, ≥10/ year	4	RP specimen score on operative quality indicators, number of nodes, node status, PIN
[Begg <i>et al.</i> 2002]	Retrospective cohort	11,522 Medicare beneficiaries, 6421 with localized disease, 403 hospitals	United States	SEER-Medicare	Age, race, stage, CCI	≤16, 17–28, 29–50, 51–120/ year	2C	Perioperative and late urinary complications
[Hu <i>et al.</i> 2003]	Retrospective cohort	2292 Medicare beneficiaries	United States	Medicare claims data	Age, race, CCI, hospital type, region, surgeon volume	<60, ≥60/ year	2C	Anastomotic stricture
[Ellison <i>et al.</i> 2005]	Retrospective cohort	12,635, 5837 with localized disease, 348 hospitals	United States	SEER-Medicare	Age, grade, stage, CCI	≤16, 17–28, 29–50, 51–120/ year	2C	Cancer control (need for adjuvant therapy)
[Alibhai <i>et al.</i> 2008]	Retrospective cohort	25,404	Canada	Canadian Institute for Health information	Age, CCI, year of surgery	–	2C	Mortality, complications

Table 1. (Continued)

Authors	Study design	Sample size (n)/ participants	Country of origin	Dataset	Statistical adjustment	Hospital volume categories	Level of evidence	Statistically significant endpoints
[Hanchanale and Javle, 2010]	Retrospective cohort	14,300, 853 hospitals	United Kingdom	Hospital episode statistics	-	≤15, 16–25, 26–37, ≥38/year	2C	Length of stay
[Trinh <i>et al.</i> 2011c]	Retrospective cohort	89,965	United States	Nationwide Inpatient Sample	Age, year of surgery, race, CCI, hospital region, academic and insurance status	1–34, 35–90, ≥91/ year	2C	Homologous blood transfusion, length of stay, intraoperative and postoperative complications
[Trinh <i>et al.</i> 2011a]	Retrospective cohort	89,883	United States	Nationwide Inpatient Sample	Age, year of surgery, race, CCI, surgical approach, hospital region and location, morbidity status, academic and insurance status	1–34, 35–90, ≥91/ year	2C	Length of stay, adverse discharge disposition
CCI, Charlson Comorbidity Index; RP, radical prostatectomy.								

Table 2. Studies examining the surgeon volume–outcomes relationship after radical prostatectomy

Authors	Study design	Sample size (n)/ participants	Country of origin	Dataset	Statistical adjustment	Surgeon volume categories	Level of evidence	Statistically significant endpoints
[Litwiller <i>et al.</i> 1995]	Retrospective cohort	428, 1 academic center, 18 surgeons	United States	Hospital records	Age, cancer stage, CCI	Continuous variable	2C	Estimated blood loss, blood transfusion, length of stay
[Leibman <i>et al.</i> 1998]	Planned clinical pathway implementation baseline analysis	856, 1 hospital, 24 surgeons	United States	Hospital records, before and after pathway implementation	–	<12, ≥12/year	1C	Length of stay, hospital charges
[Begg <i>et al.</i> 2002]	Retrospective cohort	11,522 Medicare Beneficiaries, 6421 with localized disease, 403 hospitals	United States	SEER–Medicare	Age, race, stage, CCI	1–4, 5–9, 10–15, 16–58/ year	2C	Perioperative and late urinary complications, long-term incontinence
[Hu <i>et al.</i> 2003]	Retrospective cohort	2292 Medicare beneficiaries	United States	Medicare claims data	Age, race, CCI, hospital type, region, surgeon volume	<40, ≥40/year	2C	Perioperative complications, length of stay
[Eastham <i>et al.</i> 2003]	Retrospective cohort	4629, 2 large urban centers, 44 surgeons	United States	Hospital records	PSA, stage, grade, surgery date, surgeon volume	≤10, >10/year	2C	% positive surgical margins
[Dash <i>et al.</i> 2004]	Prospective cohort	1123, 1 academic center, 9 surgeons	United States	Consecutive prospectively enrolled patients	Age, race, hormone therapy, stage, grade, prostate volume, anesthesia type	<15, ≥15/year	1B	Blood transfusion
[Bianco <i>et al.</i> 2005a]	Retrospective cohort	5238 Medicare beneficiaries, 159 surgeons	United States	SEER–Medicare	Age, stage, CCI, hospital volume	≤20, >20 within study period	2C	Perioperative and late urinary complications, long-term incontinence

Table 2. (Continued)

Authors	Study design	Sample size (n)/ participants	Country of origin	Dataset	Statistical adjustment	Surgeon volume categories	Level of evidence	Statistically significant endpoints
[Chun <i>et al.</i> 2006]	Retrospective cohort	2402 consecutive patients, 1 academic center, 11 surgeons	Germany	Hospital records	PSA, stage, grade	Continuous variable	2C	% positive surgical margins
[Jeldres <i>et al.</i> 2008]	Retrospective cohort	7937, 130 surgeons	Canada	Quebec Health Plan claims data	Age, CCI	Continuous variable	2C	Cancer control (need for adjuvant therapy)
[Vesey <i>et al.</i> 2011]	Retrospective cohort	8032, 96 centers, 212 surgeons	United Kingdom	British Association of Urological Surgeons (BAUS) Section of Oncology complex operations database	-	Continuous variable	2C	% positive surgical margins, biochemical recurrence, anastomotic strictures, intraoperative complications, estimated blood loss

CCI, Charlson Comorbidity Index; PSA, prostate specific antigen.

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