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Cost of New Technologies in Prostate Cancer Treatment: Systematic Review of Costs and Cost Effectiveness of Robotic-assisted Laparoscopic Prostatectomy, Intensity-modulated Radiotherapy, and Proton Beam Therapy

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Abstract

Context: Some of the high costs of robot-assisted radical prostatectomy (RARP), intensity-modulated radiotherapy (IMRT), and proton beam therapy may be offset by better outcomes or less resource use during the treatment episode.

Objective: To systematically review the literature to identify the key economic trade-offs implicit in a particular treatment choice for prostate cancer.

Evidence acquisition: We systematically reviewed the literature according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) statement and protocol. We searched Medline, Embase, and Web of Science for articles published between January 2001 and July 2016, which compared the treatment costs of RARP, IMRT, or proton beam therapy to the standard treatment. We identified 37, nine, and three studies, respectively.

Evidence synthesis: RARP is costlier than radical retropubic prostatectomy for hospitals and payers. However, RARP has the potential for a moderate cost advantage for payers and society over a longer time horizon when optimal cancer and quality-of-life outcomes are achieved. IMRT is more expensive from a payer's perspective compared with three-dimensional conformal radiotherapy, but also more cost effective when defined by an incremental cost effectiveness ratio <\$50 000 per quality-adjusted life year. Proton beam therapy is costlier than IMRT and its cost effectiveness remains unclear given the limited comparative data on outcomes. Using the Grades of Recommendation, Assessment, Development and Evaluation approach, the quality of evidence was low for RARP and IMRT, and very low for proton beam therapy.

Conclusions: Treatment with new versus traditional technologies is costlier. However, given the low quality of evidence and the inconsistencies across studies, the precise

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difference in costs remains unclear. Attempts to estimate whether this increased cost is worth the expense are hampered by the uncertainty surrounding improvements in outcomes, such as cancer control and side effects of treatment. If the new technologies can consistently achieve better outcomes, then they may be cost effective.

Patient summary: We review the cost and cost effectiveness of robot-assisted radical prostatectomy, intensity-modulated radiotherapy, and proton beam therapy in prostate cancer treatment. These technologies are costlier than their traditional counterparts. It remains unclear whether their use is associated with improved cure and reduced morbidity, and whether the increased cost is worth the expense.

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1. Introduction

Since the turn of the century, new technologies have revolutionized the treatment of prostate cancer. Starting in the early 2000s, intensity-modulated radiotherapy (IMRT) was rapidly adopted by radiation oncologists, such that by 2007 the vast majority of radiation for prostate cancer was delivered using this method [1]. Around the same time, surgical treatment of prostate cancer was transformed by the rapid dissemination and adoption of robot-assisted radical prostatectomy (RARP). While in 2004 <10% of radical prostatectomy procedures were performed using a robotic approach, this proportion increased to 73% by 2012 [2]. More recently, proton beam therapy has emerged as a new radiation treatment modality. This new technology diffused more slowly than IMRT and RARP, representing only 5% of radiation treatments for prostate cancer in the USA in 2012 [3]. Yet, some centers are strong proponents of its use [4], and others will build proton beam facilities in the upcoming years [5].

Treatment with any of these new technologies—IMRT, RARP, or proton beam therapy—is associated with significant upfront costs: ~\$2 million for a robotic platform and ~\$150 million for a proton beam therapy cyclotron facility [6,7]. Moreover, maintenance of the equipment and disposables come with additional expenditures [8]. However, some of these costs may be offset by better outcomes or less resource use during the treatment episode. For example, decreased adverse events [9] and shorter hospital stays [10] associated with robotic surgery may offset some of the additional cost.

To date, we lack a comprehensive review of the scientific literature on the costs and health care economics associated with these new treatments for prostate cancer. For this reason, we set out to systematically review the literature to identify the key economic trade-offs implicit in a particular treatment choice for prostate cancer. Specifically, we sought to identify cost-analysis, cost-effectiveness, cost-benefit, and cost-utility studies in the English literature, comparing the cost of each of the new technologies with its more traditional counterpart. These data can inform patients and clinicians when making treatment choices for prostate cancer.

2. Evidence acquisition

We performed a systematic review of the literature according to the Preferred Reporting Items for Systematic

reviews and Meta-analyses (PRISMA) statement and the PRISMA protocol (see Appendix A for the protocol) [11,12]. We performed three separate searches, one each for RARP, IMRT, and proton beam therapy. We systematically searched Medline, Embase, and Web of Science for manuscripts that compared treatment with one of the new technologies to treatment with the predecessor standard treatment and that reported data on cost, with cost defined as cost analysis, cost effectiveness, cost benefit, or cost utility [13]. We limited our search to manuscripts in the English language that were published between January 2001 and July 2016, and excluded editorials. Restriction to the English language was felt to be unlikely to bias our results based on a recent systematic review of empirical studies on this topic [14]. The searches were performed on July 15, 2016 (IMRT and proton beam therapy) and on July 25, 2016 (RARP). After removing duplicates, the searches yielded 362 citations for IMRT, 207 citations for proton beam therapy, and 926 citations for RARP (Fig. 1). Details about the search strategies and their results are available in Appendix B.

We excluded manuscripts that did not assess treatment of locoregional prostate cancer, did not examine the technology of interest (ie, not about RARP, IMRT, or proton beam therapy), did not include cost outcomes as defined above, were not a primary research article (eg, meeting abstract, editorial, and comment), or did not compare the technology of interest with its predecessor standard treatment (only RARP vs radical retropubic prostatectomy [RRP], IMRT vs three-dimensional conformal radiotherapy [3D-CRT], and proton beam therapy vs IMRT were included). We first excluded manuscripts based on a review of the title and abstract. Among the remaining manuscripts, we then reviewed the full text, again applying the exclusion criteria. A flow diagram of the search and selection process is shown in Figure 1.

We then systematically abstracted the evidence from the full-text manuscripts according to the protocol. We summarized the number of subjects included, type of study, comparison groups, cost definitions, perspectives (payer vs hospital vs society), and main findings. Risk of bias was assessed with a focus on selection bias, comparability of groups, and follow-up. Data were synthesized in narrative form because of the controversies surrounding methodologies to convert different types of economic outcomes published over a range of years [15]. Given the topic of this review, formal assessment of metabiases such as publication bias or selective reporting within studies was

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