A Cost-Effectiveness Analysis of Reverse Total Shoulder Arthroplasty versus Hemiarthroplasty for the Management of Complex Proximal Humeral Fractures in the Elderly

Georg Osterhoff, MD[1], Nathan N. O'Hara, MHA[2], Jennifer D'Cruz, MSc[3], Sheila A. Sprague, PhD[3,4], Nick Bansback, PhD[5,6], Nathan Evaniew, MD[4], Gerard P. Slobogean, MD, MPH[2,*]

[1]Division of Trauma Surgery, University Hospital Zurich, Zurich, Switzerland; [2]Department of Orthopaedics, R. Adams Cowley Shock Trauma Center, University of Maryland School of Medicine, Baltimore, MD, USA; [3]Department of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada; [4]Division of Orthopaedic Surgery, Department of Surgery, McMaster University, Hamilton, Ontario, Canada; [5]Centre for Health Evaluation and Outcome Sciences, Vancouver, British Columbia, Canada; [6]School of Population and Public Health, University of British Columbia, Vancouver, British Columbia, Canada

A B S T R A C T

Background: There is ongoing debate regarding the optimal surgical treatment of complex proximal humeral fractures in elderly patients. **Objectives:** To evaluate the cost-effectiveness of reverse total shoulder arthroplasty (RTSA) compared with hemiarthroplasty (HA) in the management of complex proximal humeral fractures, using a cost-utility analysis. **Methods:** On the basis of data from published literature, a cost-utility analysis was conducted using decision tree and Markov modeling. A single-payer perspective, with a willingness-to-pay (WTP) threshold of Can$50,000 (Canadian dollars), and a life-time time horizon were used. The incremental cost-effectiveness ratio (ICER) was used as the study's primary outcome measure. **Results:** In comparison with HA, the incremental cost per quality-adjusted life-year gained for RTSA was Can$13,679. One-way sensitivity analysis revealed the model to be sensitive to the RTSA implant cost and the

RTSA procedural cost. The ICER of Can$13,679 is well below the WTP threshold of Can$50,000, and probabilistic sensitivity analysis demonstrated that 92.6% of model simulations favored RTSA. **Conclusions:** Our economic analysis found that RTSA for the treatment of complex proximal humeral fractures in the elderly is the preferred economic strategy when compared with HA. The ICER of RTSA is well below standard WTP thresholds, and its estimate of cost-effectiveness is similar to other highly successful orthopedic strategies such as total hip arthroplasty for the treatment of hip arthritis.
Keywords: cost-effectiveness, cost-utility, elderly, hemiarthroplasty, proximal humerus fracture, reverse total shoulder arthroplasty.

Copyright © 2016, International Society for Pharmacoeconomics and Outcomes Research (ISPOR). Published by Elsevier Inc.

Introduction

Fractures of the proximal humerus are common debilitating fractures in the elderly. Because of the impaired bone quality and frailty in this patient population, there is an increased incidence of complex and unstable proximal humeral fractures [1,2]. Although the benefits of surgical interventions remain controversial [3], locked plate fixation has become a standard surgical treatment for many fracture patterns [4–6]. Despite the preference for internal fixation [7], fractures with complex patterns and calcar comminution can be difficult to successfully treat with plate fixation [6,8–11]; as a result, arthroplasty has increasingly been used to manage these complex fractures in elderly patients who have low functional demands [12–17].

Successful hemiarthroplasty (HA) can be challenging because anatomic healing of the tuberosities is essential to improve the postoperative functional outcome [16]. Reverse total shoulder

arthroplasty (RTSA), in contrast, has gained recent popularity because its success can be independent of tuberosity malposition or rotator cuff integrity. Although this represents a substantial design advantage, widespread adoption of RTSA has been tempered by high implant costs and sparse salvage options for failure [17]. There is ongoing debate in the orthopedic surgical community on whether RTSA or HA is the preferable management strategy of complex displaced proximal humeral fractures in elderly patients.

Recently, several clinical trials and systematic reviews [18–27] have compared both interventions with regard to their functional outcomes and their associated risks for complications. Briefly, these studies have suggested improved functional outcomes with a higher rate of complications in RTSA groups. The results of these studies enhance our understanding of the clinical effectiveness of these treatments; they, however, do not inform the economic value of each strategy. With constrained health

budgets, consideration of the cost-effectiveness of management strategies is becoming increasingly more important for both surgeons and policymakers. Therefore, the aim of the present study was to evaluate the cost-effectiveness of RTSA compared with HA in the treatment of complex proximal humeral fractures in elderly patients. This economic evaluation is based on the assumption that the treating surgeon has opted for surgical treatment, in particular, joint arthroplasty, because of the complexity of the fracture. Therefore, a nonoperative comparison was not included in the model and the included fracture pattern is deemed inappropriate for treatment using internal plate fixation.

Methods

Overview

On the basis of data from published literature, we conducted a cost-utility analysis using decision tree and Markov modeling.

A single-payer Canadian provincial government perspective (Ontario Ministry of Health) and a lifetime time horizon were used. The incremental cost-effectiveness ratio (ICER) was the primary metric of cost-effectiveness. We conducted multiple sensitivity analyses to explore the robustness of our findings. To determine which of the treatments would be the economically preferred intervention, we used a willingness-to-pay (WTP) threshold of Can$50,000 (Canadian dollars) per incremental quality-adjusted life-year (QALY) gained [28].

Model Overview

TreeAge Pro 2011 (TreeAge Software, Inc., Williamstown, MA) was used to construct a decision tree for the first 2 years of the model (Fig. 1) followed by a Markov model for the remainder of the lifetime. At the end of each node of the decision tree, a Markov process started that extended the time horizon in the decision tree for the remainder of a patient's life span (Fig. 2). Briefly, all individuals entered the Markov model with their health state
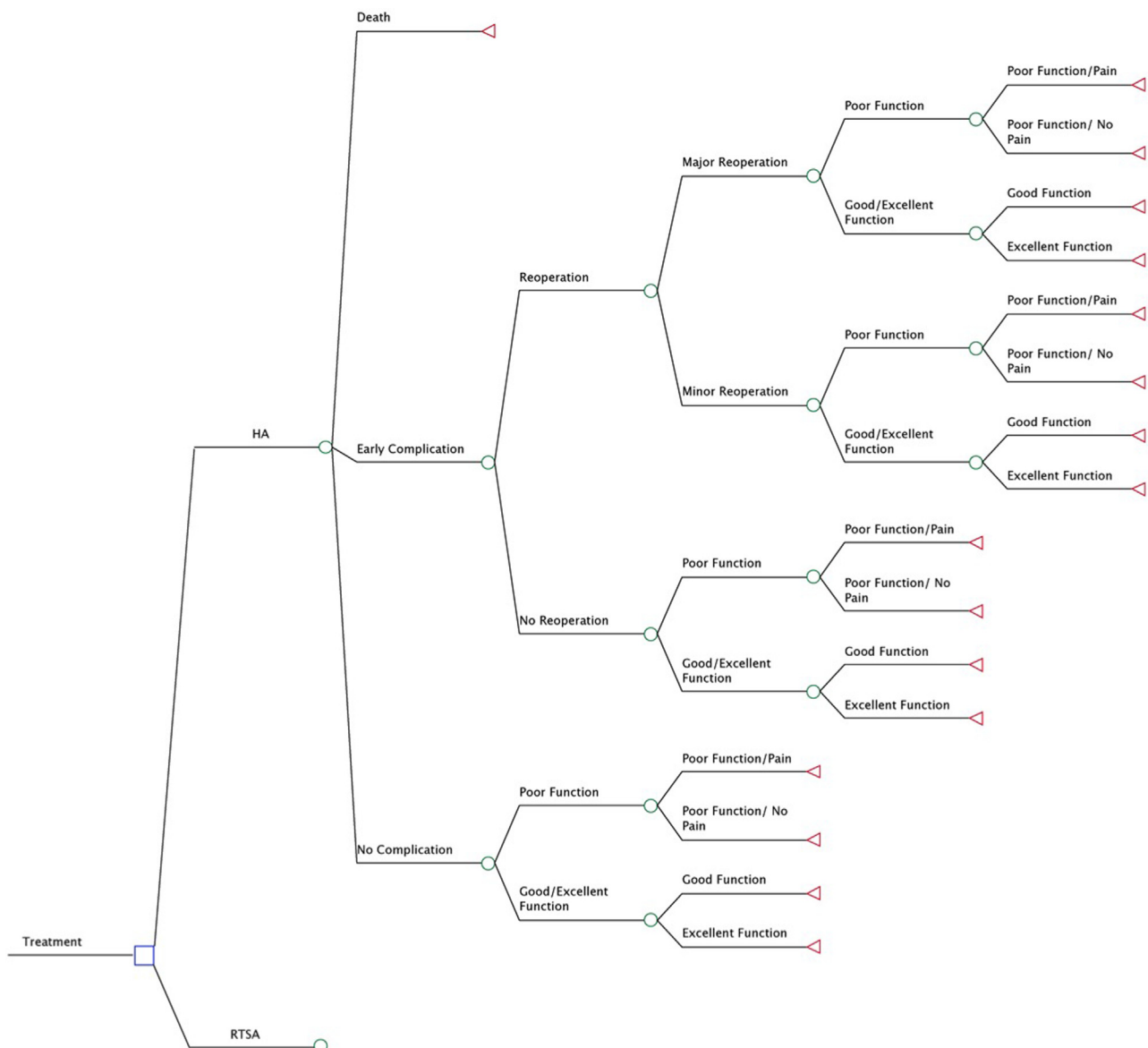

Fig. 1 – Decision tree representing the comparison of RTSA vs. HA for the treatment of complex proximal humerus fractures in elderly patients. HA, hemiarthroplasty; RTSA, reverse total shoulder arthroplasty.