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Original article

Effect of hospital volume on processes of care and 5-year survival after breast cancer: A population-based study on 25 000 women

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ABSTRACT

Purpose: To compare processes of care and survival for breast cancer by hospital volume in Belgium, based on 11 validated process quality indicators.
Methods: Three databases were linked at the patient level: the Cancer Registry, the population and the claims databases. All women with a diagnosis of invasive breast cancer between 2004 and 2006 were selected. Hospitals were classified according to their annual volume of treated patients: <50 (very low), 50–99 (low), 100–149 (medium) and ≥150 patients (high). Cox and logistic regression models were used to test differences in 5-year survival and in achievement of process indicators across volume categories, adjusting for age, tumor grade and stage.
Results: A total of 25 178 women with invasive breast cancer were treated in 111 hospitals. Half of the hospitals ($N = 57$) treated <50 patients per year. Six of eleven process indicators showed higher rates in high-volume hospitals: multidisciplinary team meeting, cytological and/or histological assessment before surgery, use of neoadjuvant chemotherapy, breast-conserving surgery rate, adjuvant radiotherapy after breast-conserving surgery, and follow-up mammography. Higher volume was also associated with improved survival. The 5-year observed survival rates were 74.9%, 78.8%, 79.8% and 83.9% for patients treated in very-low-, low-, medium- and high-volume hospitals respectively. After case-mix adjustment, patients treated in very-low- or low-volume hospitals had a hazard ratio for death of 1.26 (95% CI 1.12, 1.42) and 1.15 (95% CI 1.01, 1.30) respectively compared with high-volume hospitals.
Conclusion: Survival benefits reported in high-volume hospitals suggest a better application of recommended processes of care, justifying the centralization of breast cancer care in such hospitals.

Introduction

The link between volume and outcome in breast cancer has become clear in recent years. A meta-analysis of 12 observational studies concluded that survival after breast cancer surgery is significantly associated with high-volume providers[1]. These higher survival rates cannot be attributed to one particular process or provider, diagnosis and treatment of breast cancer being a multidisciplinary process, involving specialists in medical imaging, pathologists, oncologists, surgeons and radiotherapists, psychologists, nurses, etc. Whether higher survival rates are due to more accurate diagnosis and staging, better decision making, a more integrated multidisciplinary approach, higher rates of adequate surgical procedures, early detection of recurrence or metastases, or application of evidence-based guidelines is theoretically appealing while not formally demonstrated.

In Belgium, the national guidelines for the management of female breast cancer were recently updated[2]. In addition, a set of 32 quality indicators was constructed, validated and tested on national cancer registry data linked to individual patient claims data. This feasibility study showed that 13 indicators were measurable, of which 11 were process of care indicators[3]. Building on this previous work, the present study aimed at comparing overall survival and 11 processes of care by hospital volume in Belgium.

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Methods

Data sources

Three national databases were linked: the Belgian Cancer Registry database, the Belgian population database and an administrative database containing claims data. The linkage of these three databases was based on a unique patient identifier (social security number) and was approved by the Belgian Privacy Commission.

The Belgian Cancer Registry contains data on the incidence date, primary tumor localization and histology, differentiation grade and staging (6th edition of the TNM classification until 2009[4]) for all primary tumors, registered in a continuous longitudinal way. From this database, records of primary invasive breast tumors (ICD-10C50) with an incidence date between January 1st 2004 and December 31st 2006 were selected.

The Belgian population registry contains the vital status of all citizens living in Belgium and recorded in the population registry. For the present study, vital status and the exact date of death for deceased patients were available until December 31st 2009. This allowed a 5-year follow up for patients diagnosed in 2004, and a 3-year follow up for patients later diagnosed.

The claims database hosted by a national consortium of all sickness funds contains detailed information on all reimbursed pharmaceutical products, consultations, diagnostic and therapeutic procedures both in hospital and ambulatory settings. These data were available from January 1st 2004 until December 31st 2006.

Hospital volume

In Belgium, all hospitals are not-for-profit institutions and almost the entire population (99%) is covered by a compulsory health insurance with a very broad benefits package covering hospital care and reimbursing medical costs. Patients are free to seek care in the hospital of their choice, regardless of the distance between their home and the hospital or the status of the hospital (teaching hospital or local centre).

Each patient was attributed to one hospital following a predefined algorithm. First, patients were attributed to the hospital where the multidisciplinary team (MDT) meeting took place. If no MDT meeting occurred or if MDT meetings occurred in more than one hospital (e.g. for second opinion), the patient was attributed to the hospital where the surgery was performed. If no MDT meeting or surgery occurred or was registered, chemotherapy and finally lump sums for hospitalization were used to attribute the patient to one hospital. Patients who could not be attributed to one hospital using this algorithm were excluded from the analysis ($N = 869$).

Hospital volume was based on the annual number of patients treated by the centre as defined by the algorithm above, and was computed as the average volume over 2004, 2005 and 2006. Hospitals were categorized as very-low-volume hospitals (<50 patients per year), low-volume hospitals (50–99 patients per year), medium-volume hospitals (100–149 patients per year) and high-volume hospitals (≥150 patients per year). The last cut-off corresponds to the minimal recommended size by EUSOMA.[5]

Quality indicators

Process and outcome indicators were retrieved by a systematic literature search including international/Belgian clinical guidelines.[2] The selection process involved a multidisciplinary panel of experts evaluating the reliability, relevance, interpretability and actionability for each indicator. For all retained indicators, the rationale and the evidence base were established. Indicator specifications were elaborated, including numerator and denominator, target population, data sources, data collection procedures, and a statistical plan for data analyses. In the absence of prospective data, the quality indicators were pilot tested using Belgian Cancer Registry data and claims data from 50 039 women with invasive breast cancer over a 5-year period. A final set of 11 process indicators was measurable,[3] showing results that largely correspond to other studies in the field.[6]

Statistical models

For the survival analysis, time in days from the date of diagnosis to death or to the end of the follow up period (December 31st 2009) was used as the dependent variable. Patients alive at the end of the follow up period were censored. Cox proportional hazard models were used to assess the influence of the annual patient volume on the 5-year survival. Three risk factors were available for the regression model: the patient's age (as a continuous variable), the tumor stage (pStage if available, cStage otherwise), and the tumor differentiation grade (from grade I – well differentiated – to grade IV – undifferentiated). A separate covariate category was attributed for patients with missing covariate values. The models were first estimated without risk factors (crude estimate, Model 1) and with risk factors (risk-adjusted estimates, Model 2). The method of the robust covariance matrix was used to account for the clustering of patients within hospitals, which is the standard method in studies assessing volume–outcome relationships.[7,8] Logistic regression models were used to assess the influence of volume on the probability that a process indicator occurred. The logarithm of the volume was used as an independent variable in the regression model, and no risk factor was taken into account. The coefficient β of such a model has the following interpretation: a small percentage rise in sample size, e.g. 10%, approximately leads to a $\beta \times 10\%$ change in the odds of the outcome.[9] Estimates were also adjusted for clustering of patients within hospitals with the Generalized Estimations Equations method.[8] Finally, analysis of variance was used to compare continuous data such as age at diagnosis. Cox proportional hazard and logistic regression analyses were performed using SAS 9.1.3. (SAS Institute, Cary, North Carolina, USA).

Results

A total of 25 178 women treated in 111 hospitals between 1/1/2004 and 31/12/2006 were included in the study. Half of the hospitals ($N = 57$) was labeled as "very-low-volume" and treated 20% of the cohort. Only 14 hospitals were labeled as "high-volume" and treated 38% of the patients (Table 1). The mean and median annual volume per hospital was 76 and 48 patients respectively.

The mean age of the cohort was 60.8 years. Patients treated in very-low-volume hospitals were almost 4 years older on average than patients treated in high-volume hospitals (63.0 versus 59.3 years, $p < 0.001$) (Table 1). The completeness of reporting pathological data differed according to the hospital volume. In very-low-volume hospitals, the percentage of missing pStage data reached 15.1% compared to 5.8% in high-volume hospitals ($p < 0.001$). Similarly, the percentage of missing data on tumor grade was 16.4% in low-volume hospitals versus 9.1% in high-volume hospitals ($p < 0.001$). However, the distribution of reported stages and grades was largely similar across hospitals, whatever their annual volume (Table 1).

The observed 5-year survival was 80.2% for the entire cohort with variations according to the annual volume: 74.9%, 78.8%, 79.8% and 83.9% for patients treated in very-low-volume, low-volume, medium-volume and high-volume hospitals respectively (Fig. 1). After case-mix adjustment, patients treated in very-low-volume