1 The Relationship Between Volume and Outcome in Surgery: A Brief Introduction

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1.1 Forty Years of Studies

The first report of the relationship between volume and outcome in surgery was that from Luft et al. in 1979 [1, 2], who showed higher mortality rates in patients who underwent complex procedures in low volume centers. Since then, many different original studies and systematic reviews have reported a positive relationship between hospital volume and clinical outcome for different surgical procedures [3–7]. In particular, Birkmeyer et al. [8, 9] have clearly shown how the quality and quantity of surgical operations were related, consistent with the slogan "the more I do, the better I do". Indeed, based on millions of operations, mostly on cancer patients, a positive correlation between 30-day mortality and number of operations was confirmed both for raw and for risk-adjusted data. This was found to be relevant mainly for high-risk procedures such as pancreatic and esophageal resections. These findings were recently validated by Morche et al. [10], who performed a systematic review of the subject. Among 32 reviews on 15 different high-risk procedures, the positive correlation between volume and outcome was confirmed, although methodological quality of most of the reviews analyzed was only moderate.

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Starting from there, specific national policies have been implemented worldwide to centralize high-complexity procedures with the aim of improving the overall quality of care. Some successful European examples of these policies include those adopted in the United Kingdom, where the centralization of esophagogastric and pancreatic surgery has decreased mortality by 5% and 1%, respectively [11, 12], in Denmark, where there is a strong centralization with the highest rate of minimum number of cases per year [13], and in the Netherlands, where, similarly to the United Kingdom, the mortality rates after pancreatic resections significantly decreased from 9.8 to 3.6% [14]. However, these positive correlations between volume and outcome were found to be more evident for high-risk procedures only. Indeed, the same Dutch experience did not find any significant correlation between hospital volume and outcome after rectal surgery [15].

1.2 Some Open Questions

Despite the body of literature in favor of the volume-outcome relationship and of the consequent centralization of certain high-risk operations, many aspects require further investigation. Indeed, these volume-outcome analyses suffer some methodological limitations:

- the time perspective, which usually is limited to 30-day mortality;
- the volume cut-offs that have been reported almost arbitrarily in most of the published studies;
- the collinearity with other important determinants of hospital mortality, such as the so-called "failure to rescue", meaning that the decrease in mortality due to major complications is also dependent on the improvement of postoperative care, the quality of which is more closely related to some specific hospital characteristics (i.e., specialized intensive care unit, high nurse-to-patient ratios, etc.) than to the number of operations performed [16, 17];
- the conundrum of what is more important between surgeon volume and hospital volume, given that some operations require specific intraoperative skills (predominance of surgeon volume), and others may require major procedures during the postoperative course (predominance of hospital volume);
- the potential fallacy of extending the positive correlations between outcome and volume to low-risk procedures with a view to promoting centralization for personal/local interests.

It is important to note that there are some limitations to the centralization of surgical procedures.

- *First*, the increase in travel requirements of patients and relatives, which means increased costs for the patient's family and in general for society. Increased distance between home and hospital means prolonged waiting times, fragmentation of the continuity of care in the community, and exposure of the patients to

inconveniences and risks that should not be neglected—especially in the case of aged patients. Very few studies have investigated the patient decision-making process, but Liu et al. [18] have shown that the driving distance likely remains the main reason why patients choose to undergo complex cancer operations at low-volume centers.

- *Second*, the training of specialized surgeons should be guaranteed throughout the country without restrictions. Thus, also complex surgical procedures should be available in high-quality centers across the country, and networking among the centers might be optimized to improve the quality of care.
- *Third*, it is interesting to note that the improved outcome in high-volume centers may follow two scenarios: outcome parameters may reach a plateau after a given cut-off number of procedures or may be associated with poorer results when a given hospital reaches its limit [19]. Considering that the number of hospital beds, specialized intensivists, specialized surgeons, and specialized nurses is finite, this second scenario is not so improbable in the real world.

While waiting for new studies on the subject, surgeons, clinicians and other health professionals will have to tackle these issues on their own so as to be active runners in this important match. Hospital volume acts as a proxy measure and/or surrogate of technical and non-technical elements that need to be identified and assessed in both low- and high-volume centers [20, 21].

The debate is thriving, and we gladly introduce this collection of contributions by outstanding and world-renowned authors in the hope of sustaining it with objective data and thoughts.

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