

Decompressive hemicraniectomy for malignant middle cerebral artery territory infarction: is life worth living?

Clinical article

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Object. Although decompressive hemicraniectomy has been shown to reduce death and improve functional outcome following malignant middle cerebral artery territory infarction, there is ongoing debate as to whether surgery should be routinely performed, considering the very high rates of disability and functional dependence in survivors. Through a systematic review of the literature, the authors sought to determine the outcome from a patient's perspective.

Methods. In September 2010, a MEDLINE search of the English-language literature was performed using various combinations of 12 key words. A total of 16 papers were reviewed and individual study data were extracted.

Results. There was significant variability in study design, patient eligibility criteria, timing of surgery, and methods of outcome assessment. There were 382 patients (59% male, 41% female) with a mean age of 50 years, 25% with dominant-hemisphere infarction. The mortality rate was 24% and the mean follow-up in survivors was 19 months (range 3–114 months). Of 156 survivors with available modified Rankin Scale (mRS) scores, 41% had favorable functional outcome (mRS Score \leq 3), whereas 47% had moderately severe disability (mRS Score 4). Among 157 survivors with quality of life assessment, the mean overall reduction was 45%: 67% for physical aspect and 37% for psychosocial aspect. Of 114 screened survivors, depression affected 56% and was moderate or severe in 25%. Most patients and/or caregivers (77% of the 209 interviewed) were satisfied and would give consent again for the procedure.

Conclusions. Despite high rates of physical disability and depression, the vast majority of patients are satisfied with life and do not regret having undergone surgery.
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KEY WORDS • decompressive hemicraniectomy • depression • functional outcome • malignant middle cerebral artery territory infarction • quality of life • satisfaction • vascular disorders

DECOMPRESSIVE hemicraniectomy has been unequivocally shown to reduce death and improve functional outcome following malignant MCA territory infarction in healthy young patients.^{9,10,17,18} In a recent meta-analysis of 3 European RCTs, early surgery reduced the mortality rate from 71% to 22% and doubled the chance of a favorable functional outcome (mRS Score

\leq 3) from 21% to 43%.¹⁷ However, although the risk of persistent vegetative state was not augmented, the number of patients with moderately severe disability (mRS Score 4) was significantly increased, from 2% to 31%, accounting for approximately 60% of patients for whom surgery proved to be lifesaving.¹⁷

Whether a moderately to severely disabled patient who is “unable to walk without assistance and unable to attend to own bodily needs without assistance” constitutes a favorable and acceptable outcome remains a matter of extensive debate.¹⁴ To answer this question, patient-centered measures of well-being, such as the health-related QOL, the incidence of depression, and the level of satisfaction, should be taken into account. For this purpose, we performed a systematic review of the English-

Abbreviations used in this paper: ALQI = Aachen Life Quality Inventory; BDI = Beck Depression Inventory; BI = Barthel Index; BQ = Blau QoL Questionnaire; DH = decompressive hemicraniectomy; MCA = middle cerebral artery; mRS = modified Rankin Scale; QOL = quality of life; RCT = randomized controlled trial; SA-SIP30 = Stroke-Adapted 30-Item version of the Sickness Impact Profile; SF-36 = 36-Item Short Form Health Survey; SIP = Sickness Impact Profile; SIS = Stroke Impact Scale; VAS = visual analog scale.

language literature in an attempt to better define the outcome of this procedure from the point of view of patients and their caregivers.

Methods

In September 2010, a MEDLINE search was performed by combining the following key words: “hemispherectomy” or “craniectomy” or “decompressive surgery” or “decompression,” “middle cerebral artery” or “internal carotid artery,” “stroke” or “infarction” or “infarct,” and “quality of life” or “depression” or “satisfaction.” This preliminary search yielded 33 papers. After excluding articles not directly related to the topic in question, those written in languages other than English, and those not reporting clinical studies (review articles and letters), 12 papers were retained.^{1,3,5,6,9,12,13,15,16,18–20} A secondary search was then performed by adding papers known to the authors and screening the references of all available articles for additional relevant papers. This yielded 5 additional papers.^{2,4,7,10,11} Of these, 1 was excluded because the authors reported a series of 4 patients who underwent “strokectomy”—that is, resection of infarcted brain tissue, without craniectomy.¹¹ A total of 16 papers were thus analyzed in this review.^{1–7,9,10,12,13,15,16,18–20}

Selected papers were reviewed in detail and data were extracted using a standardized data extraction form. Information collected included study design, patient eligibility criteria, sample size, duration of follow-up, sex and age of patients, side of infarct and affected vascular territories, time to surgery, preoperative neurological condition (including clinical signs of herniation), mortality, number of patients lost to follow-up, methods of outcome assessment in survivors, functional outcome, QOL, incidence of depression, and level of satisfaction. Individual patient data were only available in 6 papers.^{1–4,12,19} Therefore, a formal meta-analysis was not possible.

Results

Study Characteristics

There were 16 studies reporting on a total of 382 patients, including 268 survivors with follow-up data.^{1–7,9,10,12,13,15,16,18–20} There were 3 RCTs,^{9,10,18} 3 prospective cohort studies,^{5,6,13} and 10 retrospective studies.^{1–4,7,12,15,16,19,20} Sample sizes ranged from 9^{4,7} to 48 patients.²⁰ Timing of surgery and prevalence of preoperative clinical herniation were highly variable. In 1 study,¹ prophylactic DH was performed before clinical deterioration on the basis of radiological and intracranial pressure data. In the remaining 15 studies,^{2–7,9,10,12,13,15,16,18–20} the indication for surgery was mass effect–related neurological deterioration despite maximal medical therapy. In some of these,^{2–4,7,15,16,19} late urgent DH was often performed in patients with clinical signs of herniation (prevalence 58.8%–100%), whereas in others^{6,9,10,13,18,20} early surgery was typically offered to neurologically deteriorating patients before clinical herniation (prevalence 9.4%–34.6%). In 2 studies,^{2,3} anterior temporal lobectomy and uncal resection were routinely performed in patients with temporal lobe infarction. Eli-

gibility criteria were also highly variable. In some studies,^{1,6,9,10,12,13,16,18} there was an upper age limit for DH ranging from 55 to 75 years, whereas in others,^{2–5,15,19,20} there were no age restrictions. In 4 studies, patients with left or dominant hemispheric infarctions were excluded,^{2,4,5,12} whereas in the remaining 12 series,^{1,3,6,7,9,10,13,15,16,18–20} the proportion of patients with left or dominant-side strokes ranged from 5.3% to 52.9%. Finally, the amount of extractable patient data varied significantly between papers, which limited the number of patients for which individual variables could be calculated (Fig. 1).

Patient Characteristics

There were a total of 382 patients. Sex distribution among 349 patients included 205 male (58.7%) and 144 female (41.3%) patients. The mean age was 50.1 years (range 11–77 years). Of 352 patients, 87 (24.7%) had dominant-side infarction. Of 316 patients with reported vascular territory, 99 (31.3%) had involvement of the anterior and/or posterior cerebral arteries in addition to the MCA. In 298 patients for whom this information was available, the mean time from symptom onset to surgery was 43.9 hours (range 6–288 hours). Clinical signs of uncal herniation (pupillary asymmetry or brainstem signs) were present preoperatively in 108 (39%) of 277 patients.

Mortality and Functional Outcome

Of the initial 382 patients, 93 (24.3%) died in the early postoperative period and an additional 22 patients (5.8%) were lost to follow-up. Functional outcome was available for 267 survivors (69.9%). In 247 survivors for whom the duration of follow-up was reported, the mean follow-up was 19.3 months (range 3–114 months).

The mRS score was assessed in 156 survivors (9 studies).^{1,5,6,9,10,12,16,18,19} Favorable outcome (mRS Score \leq 3) occurred in 64 patients (41%, range 25%–66.7%). Of 111 patients for whom this information was available, moderately severe disability (mRS Score 4) was present in 52 (46.8%, range 33.3%–73.7%) and severe disability (mRS Score 5) was found in 12 (10.8%, range 0%–24%).

The BI was assessed in 259 survivors (15 studies),^{1–6,9,10,12,13,15,16,18–20} and the mean score was 59.2 (range 0–100). The most commonly used definition for favorable outcome was a score of \geq 60, which occurred in 123 (56.2%, range 36.4%–88.9%) of 219 patients for whom this information was available. In addition, an excellent outcome (BI \geq 95) was reported in 16 (16.8%, range 8.3%–33.3%) of 95 patients.

Other functional outcome measures included the following: National Institutes of Health Stroke Scale,^{10,13,15,16,18,19} walking status,^{2,3,13,19,20} Glasgow Outcome Scale,^{3,13,15,20} and European Stroke Scale.⁶

Quality of Life Outcome

The QOL was assessed in 192 survivors (11 studies; Table 1).^{1–3,5,6,9,15,16,18–20} Of 201 eligible patients, 9 could not be assessed because of significant aphasia. Methods of QOL assessment were extremely variable across studies and included the following: Medical Outcomes Study SF-36 in 35 survivors,^{9,15} BQ in 32,²⁰ Reintegration to Normal

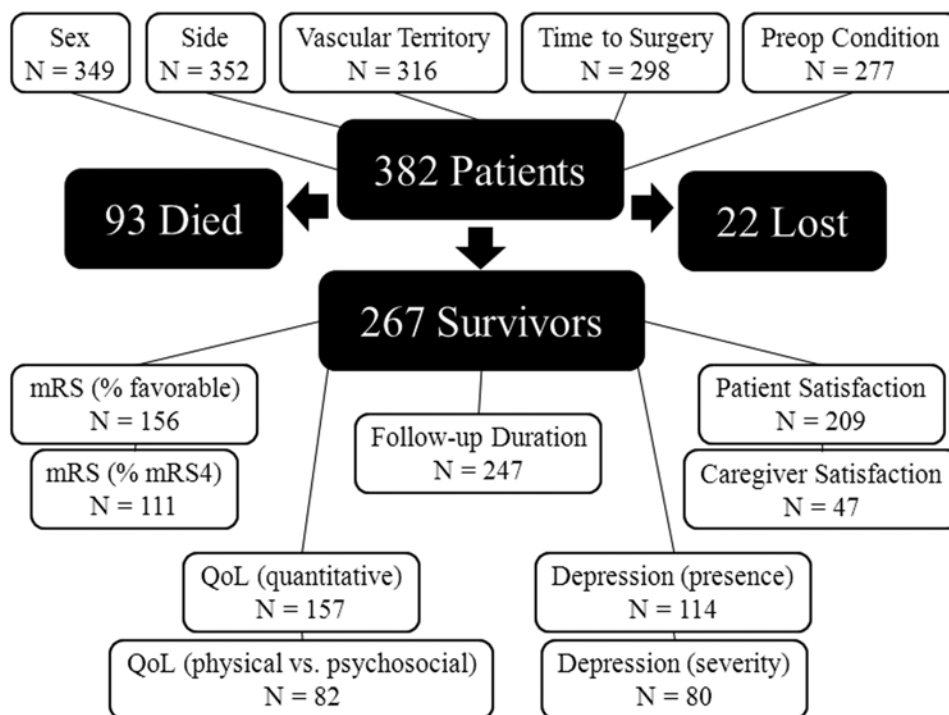


Fig. 1. Chart showing variables and corresponding sample sizes.

Living Index in 31;^{2,3} Stroke-Specific QoL Scale in 23;⁵ VAS in 23;⁹ the SA-SIP30 in 22;⁶ SIP in 19;¹ SIS in 18;^{16,18} and ALQI in 12.¹⁹

For the pooled analysis, all QOL data were converted into percentage of maximal dysfunction. Because the SF-36, BQ, RNLI, VAS, and SIS scores are expressed as the percentage of best possible QOL, percentages of dysfunction were calculated by subtracting these scores from 100%. The ALQI score was divided by 1.07 (maximal dysfunction = 107). No conversions were needed for SIP and SA-SIP30 scores. Quantitative QOL information was not available for 35 survivors.^{5,15} For the remaining 157 survivors,^{1-3,6,9,16,18-20} the mean overall QOL reduction (from a maximal score) was 45.2% (range 9%–97.5%). Separate physical and psychosocial (or mental) scores were reported for 82 survivors^{1,6,9,16,18} and were similarly converted into percentages of maximal dysfunction. The mean physical and psychosocial QOL reductions were 66.9% and 36.8%, respectively.

Depression Outcome

The presence of depression was assessed in 151 survivors (9 studies; Table 2).^{1-3,5,6,9,12,18,19} Of 165 eligible patients, 14 could not be assessed (severe neurological disability in 8, significant aphasia in 5, patient refusal in 1). Methods of depression assessment were variable and included the following: Zung Self-Rating Depression Scale in 42 survivors,^{2,3,19} BDI in 39,^{1,5} Montgomery and Asberg Depression Rating Scale in 23,⁹ Hospital Anxiety and Depression Scale in 18,⁶ and Befindlichkeitsbogen nach v. Zerssen in 14.¹² The method was not specified for 15 survivors.¹⁸

Depression was detected in 64 (56.1%, range 20%–

81.8%) of 114 survivors for whom this information was available.^{1,2,5,9,12,18,19} Moderate or severe depression was reported in 20 (25%, range 8.3%–44.4%) of 80 survivors.^{1,2,6,9,19}

Satisfaction Outcome

Patient and/or caregiver satisfaction was assessed for 223 patients (14 studies; Table 3).^{1,2,4-7,9,10,12,13,15,18-20} Of 239 eligible patients, 16 could not be assessed (aphasia in 7, reason not specified in 9). Retrospective agreement was the method used in 181 survivors:^{1,2,4-7,10,12,13,19,20} patients and caregivers were asked whether, knowing what they know now about the outcome, they would give consent again for surgery should they become confronted with the same situation. Other methods of assessment included the life satisfaction checklist (LiSat-11) for 12 survivors¹⁵ and asking whether “life was worth living” for 10.¹⁸ The method was not specified for 20 survivors.⁹

Of 209 survivors and caregivers,^{1,2,4-7,9,10,12,15,18-20} 160 (76.6%, range 37.5%–100%) were satisfied with life and/or would give consent again for DH. Caregiver satisfaction was separately assessed in 3 studies:^{1,4,9} of 47 caregivers, 44 (93.6%, range 90%–100%) were satisfied.

Discussion

Our systematic review of the currently available literature suggests that, despite a significant proportion of patients left with moderately severe (46.8%) or severe (10.8%) disability and a high rate of depression (56.1%), the vast majority of patients and/or caregivers (76.6%) expressed satisfaction with life and had no regret for having undergone DH. It must be noted that the 56.1% rate

TABLE 1: Summary of QOL assessment in 11 studies*

Authors & Year	No. of Pts	Methods	Findings
Carter et al., 1997	11	RNLI	9 pts (81.8%) had mild-to-moderate impairment; 2 pts (18.2%) had severe impairment
Walz et al., 2002	12	ALQI	psychosocial aspects less impaired than physical; no difference btwn lt- & rt-side strokes except for communication
Foerch et al., 2004	22	SA-SIP30	median score 57.8% (range 24.9–97.5%); physical aspect worse than psychosocial
Woertgen et al., 2004	32	BQ	24–48% of pts had a less adequate QOL; best score for family & worst for job; caregivers rated QOL significantly lower than pts
Curry et al., 2005	20	RNLI	moderate-to-severe decrements in QOL across all age groups
Vahedi et al., 2005	7 pts, 8 proxies	SIS	mean scores 59 ± 16% (pts) & 52 ± 17% (proxies); physical domains more affected than psychosocial; scores lower in aphasic patients, particularly for communication
Erban et al., 2006	23	SS-QOL	9 (39.1%) had a favorable outcome (score ≥60%)
Vahedi et al., 2007 ¹⁸	10	SIS	mean score 45.8%; physical domains more affected than psychosocial
Skoglund et al., 2008	12	SF-36	severe impairment in physical functioning (25–30%) & physical role (5–10%); mental summary much less affected than physical; bodily pain & emotional role similar to age-matched controls
Benejam et al., 2009	19	SIP	mean score 38.2 ± 8.4% (range 29–61%); psychosocial score better than physical; no difference btwn dominant & nondominant hemisphere strokes except for communication
Hofmeijer et al., 2009	23	SF-36; QOL VAS	mean SF-36 physical score 29 ± 7%; mean SF-36 mental score 55 ± 12%

* The mean values are expressed ± SD. Abbreviations: pts = patients; RNLI = Reintegration to Normal Living Index; SS-QOL = Stroke-Specific Quality of Life Scale.

of depression in this population is substantially higher than the 33% rate observed among stroke survivors in general,⁸ which is not surprising at all given the much higher rates of significant disability following malignant MCA territory infarction. To understand this phenomenon better, one has to perceive QOL as the combination of 2 separate components: a physical dimension and a psychosocial dimension. Whereas the former may strongly correlate with the functional outcome and may be reliably and objectively assessed by physicians, the latter is a purely subjective measure that only patients themselves

(and perhaps their primary caregivers) may reliably assess. In fact, although patients suffered severe impairment in the physical aspect of their QOL (mean 66.9%), their psychosocial dimension was only mildly to moderately impaired (mean 36.8%). This strongly supports the fact that the latter aspect is multidimensional and may depend on multiple factors besides the physical disability, including the patient's premorbid lifestyle and personality, and the presence of strong family and social support. It would have been interesting to measure the correlation between patient-centered measures of outcome (QOL, depression,

TABLE 2: Summary of depression assessment in 11 studies*

Authors & Year	No. of Pts	Methods	Findings
Carter et al., 1997	11	ZSRDS	9 (81.8%) had evidence of depression: mild to moderate in 5 (45.4%) & severe in 4 (36.4%)
Leonhardt et al., 2002	14	BF-S	6 (42.9%) had evidence of depression
Walz et al., 2002	12	ZSRDS	7 (58.3%) had evidence of depression: mild in 6 (50%) & moderate in 1 (8.3%)
Foerch et al., 2004	18	HADS	8 (44.4%) had moderate-to-severe anxiety &/or depression: 5 of 8 pts (62.5%) w/ BI <50 had depression; 2 of 10 pts (20%) w/ BI ≥50 had depression
Curry et al., 2005	19	ZSRDS	increased incidence of depression across all age groups
Vahedi et al., 2005	NA	NA	2 pts (25%) had a major depressive episode & 1 spouse attempted suicide
Erban et al., 2006	23	BDI	13 (56.5%) had evidence of depression; almost the whole study population was affected by depression at some point in time
Pillai et al., 2007	NA	NA	incidence of major depression higher in patients w/ dominant-hemisphere infarction
Vahedi et al., 2007 ¹⁸	15	not specified	3 (20%) had evidence of depression
Benejam et al., 2009	16	BDI	8 (50%) had evidence of depression; 3 (18.8%) had moderate depression; 2 (12.5%) had severe depression
Hofmeijer et al., 2009	23	MADRS	18 (78.3%) had evidence of depression; 2 (8.7%) had severe depression

* BF-S = Befindlichkeitsbogen nach v. Zerssen; HADS = Hospital Anxiety and Depression Scale; MADRS = Montgomery and Asberg Depression Rating Scale; NA = not available; ZSRDS = Zung Self-Rating Depression Scale.

Quality of life after decompressive hemicraniectomy for stroke

TABLE 3: Summary of satisfaction assessment in 14 studies*

Authors & Year	No. of Pts	Methods	Findings
Delashaw et al., 1990	8	retro agreement (custom scale: 1 = yes, 10 = no)	8 pts (100%) were satisfied (scores 1–3); 8 caregivers (100%) were satisfied (scores 1–2)
Carter et al., 1997	11	retro agreement (custom scale: 1 = definitely yes, 5 = maybe, 10 = definitely no)	6 (54.5%) said definitely yes; 3 (27.3%) said maybe; 2 (18.2%) said definitely no
Leonhardt et al., 2002	18	retro agreement	14 (77.8%) were satisfied
Walz et al., 2002	12	retro agreement	11 (91.7%) were satisfied
Foerch et al., 2004	22	retro agreement	9 (40.9%) were satisfied; 9 (40.9%) were dissatisfied; 4 (18.2%) were undecided
Gupta et al., 2004	8	retro agreement	3 (37.5%) were satisfied
Woertgen et al., 2004	32	retro agreement	26 (81.2%) were satisfied, including 91% of pts & 80% of caregivers
Erban et al., 2006	23	retro agreement (custom 3-point scale)	14 (60.9%) said definitely yes; 3 (13%) said probably no; 6 (26.1%) said definitely no
Jüttler et al., 2007	14	retro agreement	14 (100%) were satisfied
Pillai et al., 2007	14	retro agreement (custom scale: from 1 = definitely no to 5 = definitely yes)	mean score 4.4 ± 1.2
Vahedi et al., 2007 ¹⁸	10	“Is Life Worth Living?”	10 (100%) were satisfied: 4 (40%) answered “all of the time,” 4 (40%) answered “most of the time,” & 2 (20%) answered “some of the time”
Skoglund et al., 2008	12	LiSat-11	10 (83.3%) were satisfied: 5 (41.7%) had a satisfying or very satisfying life, 5 (41.7%) had a rather satisfying life, & 2 (16.7%) had a rather dissatisfying or dissatisfying life
Benejam et al., 2009	19	retro agreement	15 pts (78.9%) & 18 caregivers (94.7%) were satisfied; no difference btwn dominant- & nondominant-hemisphere strokes
Hofmeijer et al., 2009	20	not specified	20 pts (100%) & 18 caregivers (90%) were satisfied

* LiSat-11 = life satisfaction checklist; retro = retrospective.

satisfaction) and functional outcome scores (mRS, BI) in order to analyze the impact of physical disability on patient well-being. Unfortunately, in most papers, individual patient data were not reported, which limited our ability to test correlations among variables.

Our study has several limitations. First, the methodological quality of any pooled analysis is at best equal to that of the individual studies, most of which in this case were noncontrolled, retrospective series. Such studies are inherently subject to significant selection and publication biases and other methodological flaws. For instance, the vast majority (75.3%) of patients included had nondominant hemisphere infarction. Moreover, the possibility that many such patients were carefully selected for surgery by either their physicians or families cannot be underestimated. Furthermore, given the significant incidence of aphasia and cognitive dysfunction in this population, caregivers were frequently interviewed and combined patient-caregiver satisfaction rates were often presented, which may have led to overestimation of patient satisfaction. Second, there was significant heterogeneity in patient eligibility criteria (age limit, side of stroke), timing of surgery, and method of outcome assessment among the 16 studies analyzed. Third, many of the instruments used in these studies were either generic scales not specifically adapted to stroke patients or scales not previously validated in these patients, particularly those with severe stroke and/or aphasia. This is further illustrated by the wide variability of the cited rates of depression (20%–82%) in these studies.

However, despite these limitations, our study constitutes the first comprehensive effort to summarize all the currently available evidence regarding patient-centered outcome following DH for malignant MCA territory infarction. Despite the heterogeneity in study design and patient selection, findings were remarkably consistent across all examined studies, particularly in regard to QOL (physical aspect much more affected than psychosocial dimension) and satisfaction (majority of patients and caregivers satisfied). Furthermore, the demographic characteristics (sex distribution, mean age) of our study sample of 382 patients as well as the rates of mortality (24.3%), moderately severe disability (46.8% of survivors), and favorable functional outcome (41% of survivors) are all in line with the results of previous RCTs,^{9,10,17,18} suggesting that this sample is reasonably representative of the patient population with malignant MCA territory infarction typically encountered in clinical practice.

Finally, although the bulk of currently available evidence suggests that patients with malignant MCA territory infarction should be offered DH given their often acceptable QOL (particularly in its psychosocial aspect) and their high rate of satisfaction, it must be acknowledged that the final and definitive answer to this controversial question would only come from a large-scale, multicenter prospective study with regular assessments of patient-centered outcome performed using standardized instruments. Furthermore, whether these results are applicable to specific patient subpopulations, particularly patients older than 60

years of age and those with infarction of the internal carotid artery territory, remains to be seen.

Conclusions

Currently available evidence suggests that, despite their significant physical disability and a high incidence of depression, the vast majority of patients are satisfied with their life following DH for malignant MCA territory infarction and do not regret having undergone this life-saving procedure. Therefore, physicians' understanding of what constitutes a favorable or acceptable functional outcome may not necessarily reflect patients' perception. Although well-designed, large-scale prospective studies specifically examining patient-centered outcomes following DH for malignant MCA territory infarction are still lacking, the currently available evidence strongly suggests that patients should not be deprived this lifesaving procedure based on the physician's premise that an mRS score of 4 is not an acceptable functional outcome.

Disclosure

Dr. Ringer is a consultant for eV3. The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: Rahme. Analysis and interpretation of data: all authors. Drafting the article: Rahme. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Rahme. Administrative/technical/material support: Adeoye. Study supervision: Zuccarello, Kleindorfer, Ringer.

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