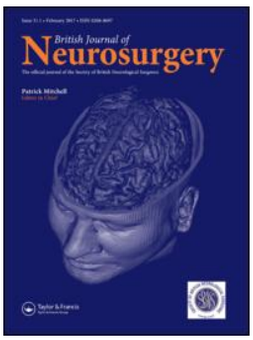

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RESEARCH ARTICLE

Relative survival after meningioma surgery. A French nationwide population-based cohort study

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ABSTRACT

Background: Survival after meningioma surgery is often reported with inadequate allowance for competing causes of death.

Methods: We processed the Système National des Données de Santé, the French administrative medical database to retrieve appropriate patients' case of surgically treated meningiomas. The Pohar Perme relative survival (RS) method was implement.

Results: A total of 28,778 patients were identified between 2007 and 2017 of which 75% were female. Median age at surgery 59 years. Cranial convexity was the most common (24.7%) location and, benign meningioma represented 91.5% of all meningioma. Median follow-up was 3.5 years interquartile range [3.4–3.5]. At data collection, 2,232 patients were dead. The five-year survival relative to the expected survival of an age- and gender-matched French standard population was 96.2% $_{95\%}$ confidence interval (CI)[95.7–96.8]. Meningioma absolute excess risk of death was 973/100,000 person-years $_{95\%}$CI[887–1068] ($p<.001$). The related standardised mortality ratio was 1.8 $_{95\%}$CI[1.7–1.9] ($p<.001$). In the adjusted model, male gender (hazard ratio [HR] =1.39, $_{95\%}$CI[1.27–1.54], $p<.001$), age at surgery (HR=0.97, $_{95\%}$CI[0.97–0.97], $p<.001$), type 2 neurofibromatosis (HR=2.95, $_{95\%}$CI[1.95–4.46], $p<.001$), comorbidities HR=1.39, $_{95\%}$CI[1.36–1.42], $p<.001$), location (HR=0.8, $_{95\%}$CI[0.67–0.95], $p=.0111$), pre-operative embolization, (HR=1.3, $_{95\%}$CI[1.08–1.56], $p=.00507$), cerebrospinal fluid shunt, (HR=2.48, $_{95\%}$CI[2.04–3.01], $p<.001$), atypical (HR=1.3, $_{95\%}$CI [1.09–1.54], $p=.00307$) or malignant histology (HR=1.86, $_{95\%}$CI[1.56–2.22], $p<.001$), redo surgery (HR=1.19, $_{95\%}$CI[1.04–1.36], $p=.0122$) and radiotherapy (HR=1.43, $_{95\%}$CI[1.26–1.62], $p<.001$) were established as independent predictors of RS.

Conclusion: This unique study highlights the excess mortality associated with meningioma disease. Many factors such as gender, age, location, histopathological grading, redo surgery influence the RS.

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Meningioma; relative survival; outcome; healthcare database; predictors

Introduction

Thought to arise from the meningothelial cells of the arachnoid, meningiomas are the most common primary intracranial extracerebral tumours accounting for 36.8%−37.6% in the Central Brain Tumor Registry of the United States.[1] Most meningiomas are sporadic and their surgical incidence is about 5/100,000 persons per year in France.[2,3] Ionising radiation, hormonal treatments and, some genetic diseases such as type 2 neurofibromatosis are identified risk factors.[4,5]

The 2016 World Health Organization (WHO) classification of tumours affecting the central nervous system (CNS) recognises three grades of meningiomas.[6] WHO grade I or benign meningiomas are the most common and, have usually a good outcome.[2,3,7] WHO grade III or malignant meningiomas are rare and aggressive neoplasms with a poor prognosis.[8] Behaviour and outcome of atypical – WHO grade II are intermediate.[9]

Management options include regular monitoring especially for incidental meningioma, symptom control, surgical excision, irradiation (radiotherapy [RT]) and, occasionally chemotherapy but, tailored maximal resection remains usually the treatment of choice. Most meningioma show an indolent course after resection but, some have an aggressive behaviour not solely related to high histopathological grade. Only a fraction of the patients who have been operated on for a meningioma will die due to the intractable course of their disease. Moreover, the majority of meningioma patients are women aged older than 50 years who may have additional co-morbidities and, an impaired health-state.

Overall survival (OS) usually underestimates the true survival rate, especially in elderly who may die from other causes. Survival study after meningioma surgery should therefore take this fact into account.

Objective

The aim of this study was to estimate relative survival (RS) after meningioma surgery and, search for associated factors using the French National Healthcare database.

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Methods

Clinical material

We performed a cross-sectional nationwide descriptive observational and, analytic retrospective study using the Système National des Données de Santé (SNDS), the national French medico-administrative database. Incidental meningiomas never operated were not considered in this study; only surgically treated tumours were taken into account. We used an algorithm combining two variables to get appropriate cases: the type of surgical procedure performed identified by the French Common Classification of Medical Acts (CCAM) and, the primary diagnosis according to the International Classification of Diseases (ICD-10) as described previously.[2,4,10,11] The 40 CCAM codes describing intracranial extracerebral tumour resection were categorised into eight anatomical locations according to their dural base insertion. Benign meningiomas were considered as corresponding to the D32 ICD-10 codes, atypical to D42 and, malignant to C70. We defined the first recorded date of meningioma surgery as the index date. Patients below 18 years were excluded ($n = 118$). Progression was defined as any new treatment for meningioma recurrence *e.g.* redo surgery, RT or stereotactic radiosurgery. The Mortality-Related Morbidity Index (MRMI) predictive of all-cause mortality were used to assess the global health-state severity.[12]

Statistical methods

For the cohort description, continuous variables are reported as medians and interquartile ranges (IQR); categorical variables are reported as frequencies and proportions. Survival was measured from the first date at meningioma surgery to the date of death or censored at last follow-up.[13] In essence, there is no lost to follow-up patient in the SNDS as those who died are automatically registered as such in the database. Moreover, due to the SNDS structure and operation, there is no missing data in any of the variables assessed in this study. To account for the lack of cause-specific survival, we performed a survival analysis of the meningioma patients relative to expected survival in the age- and gender-matched French general population. RS is thus calculated as the observed OS in the meningioma cohort relative to that expected in the French general population. We used the Pohar Perme method, a new non-parametric unbiased estimator of net survival, even in the presence of informative censoring.[14–16] All tests were two-sided and, statistical significance was defined with an alpha level of 0.05 ($p < .05$). Analysis was performed using the SAS Enterprise Guide (version 7.15 HF8, SAS Institute Inc., Cary, NC, USA) and, the R programming language and software environment for statistical computing and graphics (R version 4.1.2 (2021-11-01)).[17]

Compliance with ethical standards

This study was conducted according to the ethical guidelines for epidemiological research in accordance with the ethical standards of the Helsinki Declaration (2008), to the French data protection authority (CNIL) an independent national ethical committee, authorisation number: 2008538; to the RECORD guidelines for studies conducted using routinely-collected health data and, according to the SAMPL Guidelines.[18,19] Informed consent was not required due to the retrospective nature of the study and, the use of anonymised data, in accordance with the European General Data Protection Regulation (GRPD EU 2016/679).

Table 1. Characteristics of the 28,778 patients.

Characteristics	*n* or median	% or IQR[a]
Gender female	21,593	75%
Median age at surgery	59 years	IQR[49–68]
Age at surgery		
<50 y.	8397	29.2%
>50 y.–< 59 y.	7252	25.2%
>60 y. –< 69 y.	7327	25.5%
>70 y.	5802	20.2%
Neurofibromatosis (NF2)	165	0.6%
Cyproterone acetate	1240	4.3%
Mortality-Related Morbidity Index (MRMI)[b]	0	IQR[0–2]
0 (ref)	12,663	51.2%
1	4810	19.5%
2	2011	8.1%
3	2974	12%
≥4	2270	9.2%
Location		
Cranial convexity	7106	24.7%
Anterior skull base	3888	13.5%
Middle skull base	6132	21.3%
Posterior skull base	3484	12.1%
Falx cerebri or parasagittal	5157	17.9%
Intraventricular	206	0.7%
Spine	2805	9.7%
Pre-operative embolisation	1355	4.7%
Venous sinus invasion	3299	11.5%
Neuronavigation	10,221	35.5%
Dura mater reconstruction	6299	21.9%
Cranioplasty	1775	6.2%
CSF shunt	556	1.9%
Tumour grading		
Benign	26,319	91.5%
Atypical	1726	6%
Malignant	733	2.5%
Redo surgery for recurrence	2170	7.5%
Radiotherapy	2621	9.1%
Stereotactic radiosurgery	909	3.2%

[a]IQR: inter quartile range.
[b]Indices computed using exclusively condition-related weights.

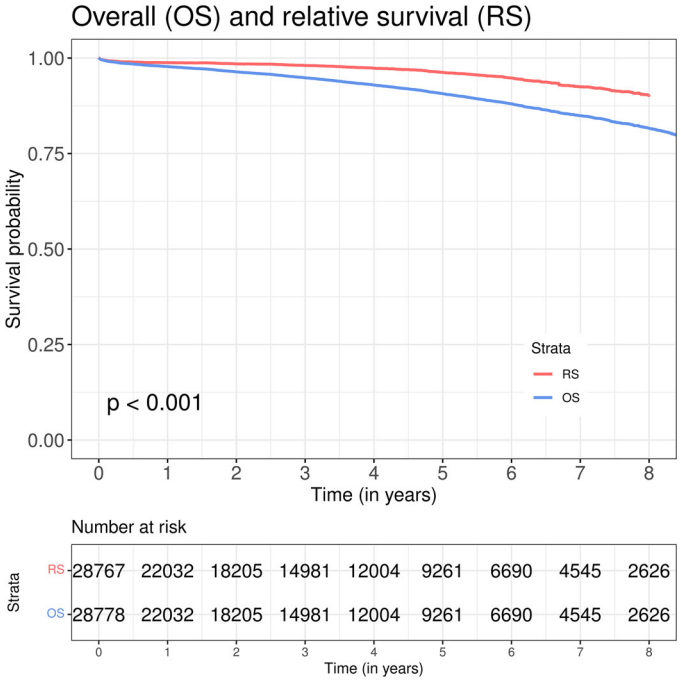

Figure 1. Plot of the meningioma overall (OS) and relative (RS) survival.

Results

Population description

We identified 28,778 patients who had meningioma surgery between 2007 and 2017. Seventy-five percent were female and, median age at meningioma first surgery was 59 years, IQR [49–68]. According to the MRMI index, male had significantly more co-morbidities compared to female ($p < .001$). Cranial convexity was the most common (24.7%) location followed by middle skull base (21.3%) (sphenoid wing). Spinal tumours accounted for 9.7%. Benign meningioma represented 91.5%, atypical 6% and, malignant 2.5% (Table 1). Median follow-up was 3.5 years IQR [3.4–3.5].

Table 2. Univariable relative survival (RS) after meningioma surgery.

	Univariable		
Variable	RS[a]	[95 %CI][b]	*p* Value
Gender			
Male	93.5%	92.1–94.9	
Female	97.2%	96.7–97.7	**<.001**
Age at surgery			
<50 y.	97.6%	97.1–98.1	
>50 y.–< 59 y.	97.6%	96.9–98.2	
>60 y.–< 69 y.	95.0%	94.0–96.0	
>70 y.	94.1%	92.1–96.1	**<.001**
Neurofibromatosis (NF2)			
Absent	96.3%	95.8–96.8	
Present	89.0%	82.8–95.7	**.00273**
Cyproterone			
Absent	96.2%	95.7–96.8	
Present	96.6%	94.6–98.7	.097
Mortality-Related Morbidity Index (MRMI)			
0 (ref)	101.2%	100.8–101.6	
1	98.3%	97.2–99.5	
2	95.6%	93.3–98.0	
3	87.4%	85.1–89.7	
≥4	73.8%	70.6–77.0	**<.001**
Cranial convexity (ref)	96.8%	95.8–97.8	
Anterior skull base	95.7%	94.3–97.0	
Middle skull base	96.5%	95.5–97.5	
Posterior skull base	95.8%	94.5–97.1	
Parasagittal	94.5%	92.7–96.3	
Falx cerebri	93.6%	91.4–95.7	
Intraventricular	89.5%	83.0–96.5	
Spine	100.5%	98.5–102.5	**<.001**
Pre-operative embolisation			
Absent	96.4%	95.9–97.0	
Present	92.7%	90.3–95.1	**.00288**
Venous sinus invasion			
Absent	96.4%	95.9–97.0	
Present	95.0%	93.4–96.6	**.0126**
Dura mater reconstruction			
Absent	96.4%	95.8–97.0	
Present	95.9%	94.8–96.9	.466
Cranioplasty			
Absent	96.4%	95.9–97.0	
Present	93.8%	91.8–95.8	**.00309**
CSF shunt			
Absent	96.7%	96.1–97.2	
Present	76.9%	72.0–82.1	**<.001**
Tumour grading			
Benign	97.0%	96.5–97.6	
Atypical	93.9%	91.7–96.2	
Malignant	73.0%	67.9–78.4	**<.001**
Redo surgery for recurrence			
No	97.0%	96.5–97.6	
Yes	90.6%	88.8–92.4	**<.001**
Radiotherapy			
No	97.5%	97.0–98.1	
Yes	87.0%	85.1–88.9	**<.001**
Stereotactic radiosurgery			
No	96.2%	95.7–96.7	
Yes	97.7%	95.7–99.8	.376

Note: p Values displayed in **bold** reached the statistical significance.
[a]Hazard ratio.
[b]95% confidence interval.

Outcome

At data collection, 2232 patients were dead. Median age at death was 73.2 years, IQR [63.9–80.9]. A total of 179 patients (0.63%) died within the first post-operative month, 303 (1.06%) within the three post-operative months and, 570 within a year (1.98%). Five-year OS was 90.7%, $_{95\%}$ confidence interval (CI) [90.2–91.1] (Figure 1(A)). The five-year survival relative to the expected survival of an age- and gender-matched French standard population was 96.2% $_{95\%}$CI [95.7–96.8], suggesting that meningioma contributed to overall mortality (Figure 1(B)). Meningioma absolute excess risk of death was 973/100,000 person-years, $_{95\%}$CI [887–1068] (p <.001). The log-rank test p value between observed ($n = 2232$) and expected ($n = 1239$) survival curves was strongly significant ($p < .001$). The related standardised mortality ratio was 1.8 $_{95\%}$CI [1.7–1.9] ($p < .001$).

Predictors of the relative survival

Most of the variables studied reached the statistical significance and, were associated to the RS in univariable analyses (Table 2). In the adjusted model, male gender (HR = 1.39, $_{95\%}$CI [1.27–1.54], $p < .001$), age at surgery (HR = 0.97, $_{95\%}$CI [0.97–0.97], $p < .001$), type 2 neurofibromatosis (HR = 2.95, $_{95\%}$CI [1.95–4.46], $p < .001$), comorbidities HR = 1.39, $_{95\%}$CI [1.36–1.42], $p < .001$), location (HR = 0.8, $_{95\%}$CI [0.67–0.95], $p = .0111$), pre-operative embolization, (HR = 1.3, $_{95\%}$CI [1.08–1.56], $p = .00507$), cerebro-spinal fluid (CSF) shunt, (HR= 2.48, $_{95\%}$CI [2.04–3.01], $p < .001$), atypical (HR = 1.3,

Table 3. Multiplicative regression model for relative survival (RS) after meningioma surgery[c].

	Multivariable		
Variable	HR[a]	[$_{95\ \%}$CI][b]	*p* Value
Gender (ref.: female)			
Male	1.39	1.27, 1.54	**<.001**
Age at surgery (continuous)	0.97	0.97, 0.97	**<.001**
Neurofibromatosis (NF2) (ref.: No)			
NF2	2.95	1.95, 4.46	**<.001**
Mortality-Related Morbidity Index (MRMI) (continuous)	1.39	1.36, 1.42	**<.001**
Location (ref.: cranial convexity)			
Anterior skull base	1.26	1.08, 1.47	**.00409**
Middle skull base	1.22	1.05, 1.4	**.00853**
Posterior skull base	1.27	1.08, 1.5	**.00457**
Falx cerebri	1.01	0.85, 1.2	.891
Intraventricular	1.76	1.11, 2.81	**.0165**
Spine	0.8	0.67, 0.95	**.0111**
Pre-operative embolisation (ref.:no)			
Yes	1.3	1.08, 1.56	**.00507**
CSF shunt (ref.:no)			
Yes	2.48	2.04, 3.01	**<.001**
Tumour grading (ref.: benign)			
Atypical	1.3	1.09, 1.54	**.00307**
Malignant	1.86	1.56, 2.22	**<.001**
Redo surgery for recurrence (ref.:no)			
Yes	1.19	1.04, 1.36	**.0122**
Radiotherapy (ref.:no)			
Yes	1.43	1.26, 1.62	**<.001**

Note: p Values displayed in **bold** reached the statistical significance.
[a]Hazard ratio.
[b]95 % confidence interval.
[c]Computed with the Andersen *et al.* method.

$_{95\%}$CI [1.09–1.54], $p = .00307$) or malignant histology (HR = 1.86, $_{95\%}$CI [1.56–2.22], $p < .001$), redo surgery (HR = 1.19, $_{95\%}$CI [1.04–1.36], $p = .0122$) and RT (HR = 1.43, $_{95\%}$CI [1.26–1.62], $p < .001$) were established as independent prognostic factors of RS (Table 3).

Discussion

Key results

In standard survival analysis, subjects are supposed to experience only one type of event, commonly recurrence or death. In reality, several types may occur. In these cases, other events – so-called competing event (CE) – may preclude the occurrence of the event of interest or modify the risk that the primary endpoint occurs. Traditional methods of survival analysis such as Kaplan–Meier method and, the Cox proportional hazards model are not designed to accommodate the competing nature of multiple events as assuming the absence of competing risk (CR). Net survival describes the probability of surviving a tumour diagnosis in the absence of competing causes of death. It is defined as the survival which might occur if all risks of dying from other causes than the disease of interest, here meningioma, were removed. Net survival is now a major epidemiological indicator routinely estimated for many neoplasms either by cause-specific survival (CSS) or by RS. The first one requires to know the cause of death. However, when causes of death are unavailable or unreliable, net survival may be assessed by the RS, which uses the all-cause mortality of the study group and, the 'expected' mortality of a disease-free group having the same demographic characteristics.[20] As such, this work represents a unique modern population-based analysis on meningioma patients mortality. Derived from an unselected sample, this study of RS after meningioma surgery and its predictors using the national database, fill a hitherto existing gap in the literature. The RS analysis presented here indicates that meningioma is a component of the cause of mortality in the affected population.

Limitations

The strengths of the SNDS reside both in high number of patients and, in exhaustive data available from every hospital in France. The database representativeness is nearly perfect, since it includes the whole country's population of 68 million inhabitants constituting one of the largest AMDB in the world.[21] Compiled from a number of institutions, its accuracy is limited by inconstancies in data collection and recording. Despite some limitations, the SNDS is an invaluable tool to assess meningioma outcome. It offers an incomparable mean to explore associations with other pathology, medication or combine surgical treatment which has and could not be assessed before. The retrospective nature of this study, together with the lack of clarity regarding treatment rationales and, non-homogeneous management strategies without random assignment, needs to be considered when evaluating the results.

Interpretation

Only a handful of studies have reported on meningioma RS. In a 1989 Norwegian study, Helseth *et al.* were the first to describe a five-year RS rate (RSR) of 84% for 1438 patients below 60 years.[22] Kallio *et al.* & Sankila *et al.* from the neighbouring country Finland, found five-year RSRs of 86.9%, $_{95\%}$CI [84–89] and, 88%, respectively.[23,24] Moreover, Sankila *et al.* noticed that the patients' RSR significantly increased during the study time

Table 4. Literature review of relative survival (RS) meningioma studies.

Author Country Year	Period considered *n*	% of female Age at surgery	% by grade I, II, III	5-year RS All grades, I, II, III	Significant factors
Present study	2007–2017	75%	91.5%	96.2%	Gender
	28,778	59 ±13.5 years	6%	97.0%	Age
			2.5%	93.9%	Location
				73.0%	Grade
					…
Brodbelt	1999–2013	70.1%	79.5%	NA[a]	Gender
UK	15,417	57.5 ±14.4 years	18.4%	90%	Age
2019			2.1%	80%	Spine
				30%	Grade
Holleczek	2000–2015	72%	70%	NA	Gender
Saarland	992	63 years	28%	96.8%	Age
2019			3%	95.6%	Grade
				61.2%	
Dolecek	2004–2011	73.3% NA	94.3%	NA	Age
USA	42,194		4.2%	85.6%	Gender
2015	(51,065)		1.5%	82.3%	Race
				66.0%	Grade
					Spine
Woehrer	2005–2010	74.4%	89.1%	I: 96%	Grade
Austria	2149	60.05 ± 14.2 years	10.9%	II: 86.9%	Histology
2014			NA%	NA	
Sankila	1959–1984	69.9%	94.3%	All grades	Gender
Finland	1560	53 years	4.7%	88%	Age
1992			1%	NA	Time
Kallio	1953–1980	70.5%	94.3%	All: 86.9%	Resection grade
Finland	935	50 years	4.7%	I: 87%	Performance status
1992			1%	II/III: 81%	Anaplasia
					Hyperostosis

[a]Not Available.

between the first (1953–1968) and, the second (1968–1978) period.[24] This was confirmed by Brodbelt *et al.* who observed that outcome after meningioma surgery has improved over the period examined.[25] This about 10% increase of the RSR within the past 30 years, are coherent with progresses made in meningioma surgical techniques, anaesthesiology, regardless the life expectancy increase (Table 3). Unsurprisingly, besides a time influence, Sant *et al.* found also a spatial variation of meningioma RS, with an average five-year rates of 88.7%, ranging from 79.5% in Eastern Europe to 93.4% in Northern Europe.[26] Comparison between the few available studies is however somewhat uncertain regarding the different statistical methods used.

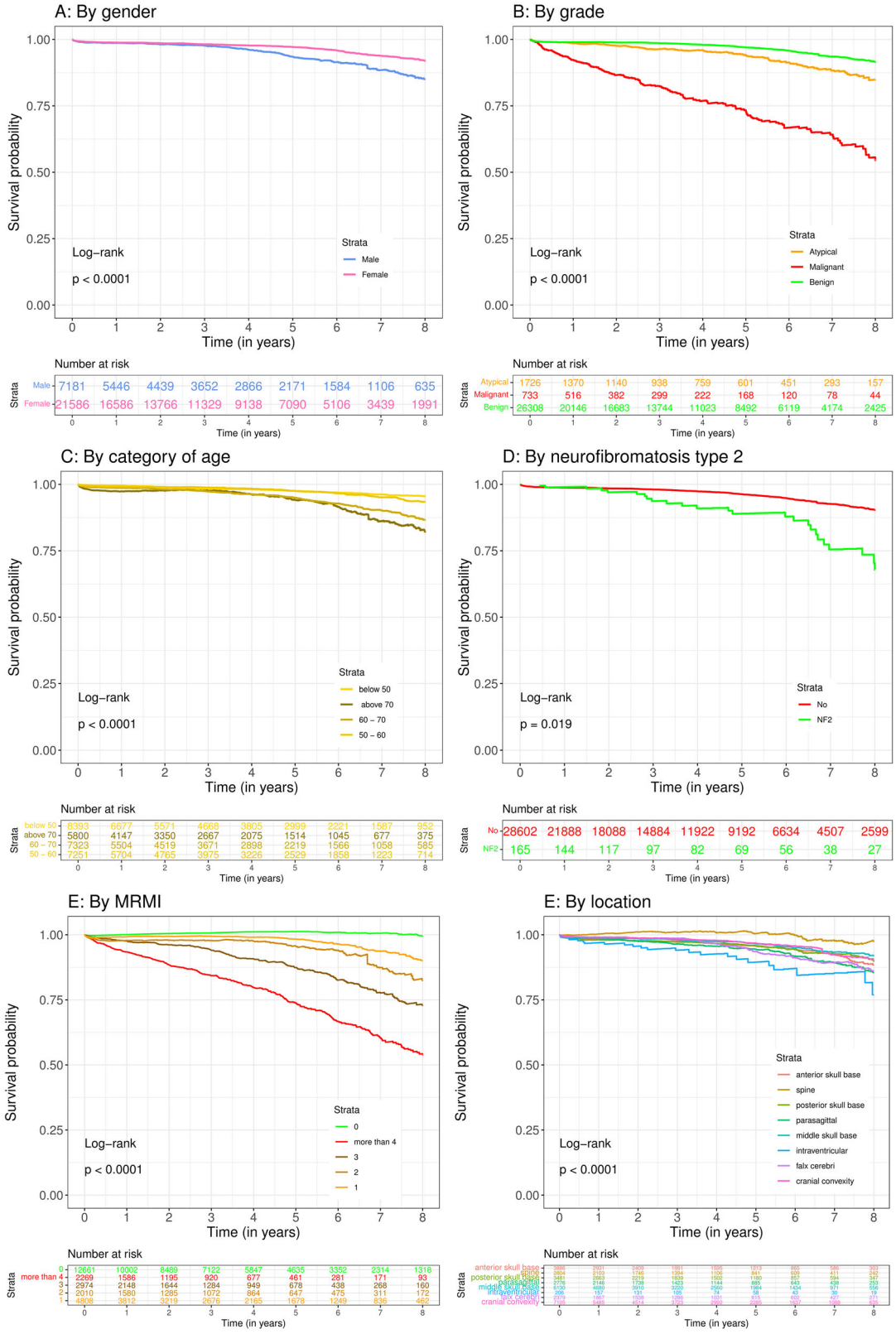

Figure 2. Relative survival curves comparisons.

Nonetheless, the population-based cohort we described here, is alike previous studies with predominant proportions of female between 70 and 75% and, a mean age at surgery ranging from 50 to 63 years (Table 3). However, the five-year RSR of 96.2%, $_{95\%}$CI [95.7–96.8] we present in this modern series, is the highest reported.

Prognostic factors

Meningioma-related excess mortality has been shown to vary according to several factors, of which gender and age have been found in most studies, including ours (Table 4).[24,25,27] Without surprise, RS after meningioma surgery is better for younger adults and, for female. On contrary, for Sankila *et al.*, long-term excess mortality was associated with young, male patients: in the age group younger than 45 years, the relative risk was 3.8 times greater for men than women; no such difference was found in the oldest age group.25 For Brodbelt *et al.* there was a significant reduction in five-year net survival over the age of 69 years, to less than 83% in men and 87% in women.[25] Of patients aged $\leq$ 54 years, 10-year RS was 95% compared to 90% in older patients ($p < .001$) in the study by Holleczek *et al.*[27] In Dolececk *et al.* report, RSRs were similar for age groups until about age 55 years when survival became progressively less favourable with advancing age groups.[28]

Better outcome for females has already been described for many tumours and, is attributed to fewer co-morbidities and/or higher clinical performance.[29] Our findings agree this statement with male having significantly more co-morbidities compared to female ($p <$ .001). One point of MRMI significantly decreased the RSRs. This effect was even more prominent for those having a high level of co-morbidities, with a RSR of solely 73.8%, $_{95\%}$CI [70.6–77.0] for the patients having a MRMI of 4 or more (Figure 2(F)).

NF2 patients are predisposed to develop CNS lesions including intracranial and spinal meningiomas that are frequently multiple and, develop at a young age.[30] In our study, NF2 patients had a significant mortality excess with a median age at death of 40 years, IQR [29–47]. Similar findings have been made by Otsuka *et al.* who conclude that long-term survival rates of patients with NF2 were shown to be unfavourable, especially for those whose symptoms started before the age of 25 years.[4,31]

One advantage of the SNDS which uses the CCAM classification, is its ability to provide a precise location of the meningioma dural insertion. The majority of meningiomas are usually situated intracranially (~90%) and, convexity is the most common location in one fourth (24.7%). RSR is better for convexity meningiomas (96.8%, $_{95\%}$CI [95.8–97.8]) and, the lowest for intraventricular ones (89.5%, $_{95\%}$CI [83.0–96.5]). Nine point seven percent of the meningiomas were removed out of the spine, *vs.* 4.4% for Dolecek *et al.* and, 7.7% for Brodbelt *et al.* who assert that patients with spinal meningiomas did better in all grades, genders and ages.[25,28] We agreed this statement by founding that spinal meningioma is not a life threatening condition and that its removal does not alter the survival.

Histopathological grading has often been shown as to be one of the strongest factor of survival. As for Holleczek *et al.*, patients with benign meningiomas had a five-year RS of 97% and, thus a minor meningioma-related excess mortality. Considering only benign meningioma, based on an analysis of 205 patients from 1985 to 2003, they found a five-year RSR of 92%, which is slightly below the herein observed rate.[32] Five-year RSR for patients with atypical meningiomas spanned from 80% up to 96% which demonstrates the significant increase in tumour-related excess mortality along the WHO grade progression.[27] Regarding malignant meningiomas, RSRs extended from 30% up to 73.0% in our study.[27] For Porter *et al.*, five-year RS of malignant meningioma was 67.3% $_{95\%}$CI [58.6 − 74.6] and, 88.7% $_{95\%}$CI [87.1 − 90.1] for non-malignant meningioma.[33] Five-year RSRs for benign, borderline malignancy and malignant were 85.6%, 82.3% and 66.0%, respectively, in Dolececk *et al.* study.[28] In the last CBTRUS report, five-year RSR for non-malignant meningioma (2004–2015) was 88.0%, $_{95\%}$CI [87.8–88.3] and, 67.7% $_{95\%}$CI [66.2–69.3] for malignant ones (2001–2015).1 Grading of meningiomas has often been controversial, especially for grades II and III which definition changed along WHO classification updates. That may partly explained the observed variations of RSRs. Obviously, the behaviour of meningiomas cannot be accounted by histological characteristics alone, as expressed by Dolececk *et al.* who found that for benign cases, five-year RS was significantly more favourable for females than males; blacks than whites; Hispanics than non-Hispanics; spinal meningiomas than other primary site locations.[28] Despite a generally indolent biological behaviour, the outcome of patients treated for meningioma may occasionally be poor and, in this study, those who needed reoperation or RT have a reduced RS of 90.6%, $_{95\%}$CI [88.8–92.4], 87.0% and $_{95\%}$CI [85.1–88.9], respectively.

Conclusion

This unique study highlights the excess mortality associated with meningioma disease of which many factors such as gender, age, location, histopathological grading, redo surgery or RT needed for aggressive tumours, influence the RS.

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Ethical approval

This study was conducted according to the ethical guidelines for epidemiological research in accordance with the ethical standards of the Helsinki Declaration (2008), to the French data protection authority (CNIL) an independent national ethical committee, authorisation number: 2008538; to the RECORD guidelines for studies conducted using routinely-collected health data and, according to the SAMPL Guidelines.[18,19] Informed consent was not required due to the retrospective nature of the study and the use of anonymised data, in accordance with the European General Data Protection Regulation (GRPD EU 2016/679).

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Data availability statement

Restricted, the authors do not have permission to share data.

Code availability

On demand.

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