

Trends in operating room-based glaucoma procedures in France from 2005 to 2014: a nationwide study

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ABSTRACT

Purpose To report the trends in operating room-based glaucoma procedures from 2005 to 2014 in France.

Methods We identified operating room-based glaucoma procedures (trabeculectomies, deep sclerectomies, aqueous shunts and ciliary body destructions) performed in France from 2005 to 2014 by means of billing codes from a national database. The annual rates and incidence of these procedures per 100 000 inhabitants were analysed globally and in three age groups: 0–14 years, 15–59 years and over 60 years.

Results The annual rate of trabeculectomies decreased slightly during the study period, while the rate for other surgical techniques (deep sclerectomies, aqueous drainage procedures and ciliary body destructions) increased. The overall rate of glaucoma surgeries was higher in areas with populations of African descent than in areas predominantly composed of Caucasian populations: 1.60 (95% CI 1.51 to 1.70, $p < 0.0001$).

Conclusions Trabeculectomy was the most commonly performed operating room-based glaucoma procedure in France from 2005 to 2014. Other modalities such as deep sclerectomies, aqueous drainage procedures and ciliary body destruction gained greater acceptance among French ophthalmologists during this 10-year period.

INTRODUCTION

Glaucoma is the leading cause of irreversible blindness worldwide¹ and according to recent estimations, the prevalence of glaucoma will continue to grow during the coming decades.² Although several risk factors for glaucoma have been identified, the only modifiable risk factor is intraocular pressure (IOP). Decreasing IOP is also associated with better control of glaucoma progression.³ Several IOP-lowering options are available: medical treatments, lasers and surgical procedures.⁴ Most often these treatment modalities are combined during the life of a patient with glaucoma. Moreover, they interact with each other and an advantageous risk-benefit balance of a given strategy may impact the number of other treatment modalities. This was particularly the case for the number of glaucoma surgeries, which decreased dramatically in the late 1990s after prostaglandin analogues became available.⁵ Bringing a patient to the operating room for a glaucoma procedure (for glaucoma surgery or a physical agent for ciliary body destruction) is generally regarded as an important step by patients and

their relatives.⁶ Moreover, it involves an additional cost to society due to the number of healthcare professionals involved in these procedures: nurses, anaesthesiologists and eye surgeons.⁷ The use of big data in ophthalmology has given rise to several reports on cataract, glaucoma and vitreoretinal surgical procedures.⁸ Even though a cautious approach is recommended when using big data, the yield of such a large amount of information is useful to follow the trends in eye surgery at the scale of a country like France with its 66 million inhabitants.⁹

In this study, we aimed to describe the changes in operating room-based glaucoma procedures in France over a 10-year period.

METHODS

Data source

The national administrative database (PMSI) was established in France in 1991 and extended in 1997 to the 1546 French healthcare facilities, both private and public. It is a coding system initially designed to analyse hospital and clinic activity to help design strategic healthcare plans. Since 2004, public and private hospital budgets are based on the medical activity recorded in the abstracts of this programme related to all hospitalisations (ambulatory and non-ambulatory). Information in these abstracts is anonymous and includes both medical and administrative data. Diagnosis coding is based on the 10th edition of the International Classification of Diseases. Procedures performed during the stay in healthcare facilities are coded according to the French Common Classification of Medical Procedures (CCAM). The standardised anonymous data set produced in each facility is compiled at a national level.

Data extraction

The use of the PMSI database was approved by the National Commission for Data Protection (Commission Nationale de l'Informatique et des Libertés no. 1576793) and this study adhered to the tenets of the Declaration of Helsinki. We included all patients who were admitted to all the French healthcare facilities during the 2000–2014 period for operating room-based glaucoma procedures. For each patient, glaucoma surgery was identified by the CCAM codes (table 1). Only patients living in mainland France and in overseas departments were included.

We focused on the most frequent surgical procedures (trabeculectomy and deep sclerectomy) and

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Table 1 Surgical glaucoma procedure codes according to the French Common Classification of Medical Procedures

BEPA004	Sectorial or peripheral iridectomy
BEPA003	Trabeculotomy performed via a sclerotomy
BEPB001	Goniotomy
BEJB004	Aqueous humour drainage
BEPA002	Surgical cyclodialysis
BEGA002	Removal of an aqueous humour drainage device
BEMA008	Bleb revision
BGFA014	Deep sclerectomy
BGFA900	Viscocalanoplasty
BENA002	Ciliary body partial destruction
BEFA008	Trabeculectomy

aqueous humour drainage procedures and cyclodestructions, which accounted for 79.6% of all the operating room-based glaucoma procedures.

Statistical analysis

Incidence rates of glaucoma surgery were calculated for the entire period, for each year and per age category. The numerator was the number of glaucoma surgeries in patients living in France. The denominator, that is, the number of inhabitants in mainland France and overseas departments, was obtained from the census data of the French National Institute of Statistics and Economic Studies (INSEE). No CIs were estimated because we studied the entire French population. The number of French ophthalmologists per department and per region was retrieved from a national data set of medical doctors (DRESS).¹⁰ The age-standardised incidence rates of glaucoma surgery for the French and European populations were calculated.¹¹ Incidence rate ratios (IRR) between mainland France and two overseas departments (Guadeloupe and Martinique) were estimated using Poisson regression with and without adjustment on the year of surgery, gender and 5-year age category. Analyses were performed with the SAS V9.4 software for Windows (The SAS Institute). The tests were two-sided and *p* values <0.05 were considered significant.

RESULTS

A total of 203 570 glaucoma procedures (136 115 patients) performed during a hospitalisation (ambulatory or non-ambulatory)

were identified from 2005 to 2014. The glaucoma surgical rates gathering all the procedures listed in [table 1](#) are displayed in [table 2](#). They decreased slightly from 2006 to 2014 and were higher in older patients.

We also considered the overall procedures for glaucoma and the relation with the density of ophthalmologists according to the mapping of the country by department and region, 100 and 14, respectively. We found a moderate correlation for regions, but not for departments (Pearson correlation coefficient), $r=0.630$ and $r=0.049$, respectively. Since the population of African descent is at greater risk for developing glaucoma than Caucasians,¹² we analysed the rate of glaucoma surgeries in the French Indies located in the Caribbean. The incidence of glaucoma surgery was statistically higher in the French Indies (Martinique and Guadeloupe) than in France's other departments in univariate analysis; the IRR=1.40 (95% CI 1.35 to 1.45, $p<0.0001$). After adjustment on year, gender and age, the difference for the IRR remained statistically significant: IRR=1.60 (95% CI 1.51 to 1.70, $p<0.0001$). [Table 3](#) displays the trends for trabeculectomy. During this 10-year period, the number of trabeculectomies decreased slightly in the older age group by 16.9% while it increased in the paediatric group by 54.6%.

Deep sclerectomy increased by 68.5% in the age group 60+ years during the study period ([table 4](#)). Canaloplasty, another non-penetrating glaucoma surgery, is not very popular in France, and the number of this surgical procedure was 1019 during the 10-year study period, that is, about 100 per year with no pronounced changes over time (data not shown).

The proportion of the two main glaucoma surgeries, trabeculectomy and deep sclerectomy, combined with cataract extraction decreased overtime: 46.2% and 49.2% in 2005 vs 30.4% and 39.8% in 2014, respectively. These combined surgeries are included in the numbers of surgeries displayed in [tables 3](#) and [4](#). The number of surgeons doing glaucoma surgery was available for the last 3 years of the study period and decreased from 713 to 610 for trabeculectomies and from 288 to 263 for deep sclerectomies, respectively. Aqueous humour drainage surgeries increased 4.4-fold during the study period, particularly in the paediatric age group ([table 5](#)).

Ciliary body destructions encompass all techniques used to decrease aqueous production, the most popular in France being cyclophotocoagulation with a diode laser. This glaucoma treatment modality increased by 73.0% during this 10-year period, particularly in older patients ([table 6](#)).

Table 2 Glaucoma surgical rates in France from 2005 to 2014

Year	Glaucoma surgical rate per 100 000 inhabitants			French population standardised incidence rate of glaucoma surgery	European population standardised incidence rate of glaucoma surgery
	Overall*	≥40 years*	≥60 years*		
2005	28.36	55.76	106.77	29.36	21.34
2006	33.26	65.42	124.75	34.14	24.97
2007	32.00	62.46	117.29	32.53	24.01
2008	32.07	61.85	113.72	32.31	24.13
2009	29.85	57.17	103.97	29.82	22.41
2010	29.51	55.97	100.76	29.27	22.05
2011	29.08	55.09	97.60	28.68	21.59
2012	28.84	54.00	94.86	28.21	21.44
2013	28.28	52.46	91.81	27.41	20.79
2014	28.57	52.63	89.44	27.48	21.08
2005 to 2014	29.97	57.17	103.42	29.92	22.38

*Crude incidence rate.

Table 3 Incidence and number of trabeculectomies performed in France from 2005 to 2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Crude incidence	15.14	15.42	14.93	14.86	14.42	13.88	13.62	13.35	13.08	12.55
Standardised incidence*	11.30	11.52	11.20	11.09	10.89	10.56	10.15	9.98	9.63	9.36
Surgical rate in the age group 0–14 years	1.21	1.02	1.20	1.10	1.06	1.41	1.27	1.34	1.76	1.78
Surgical rate in the age group 15–59 years	4.80	4.84	4.91	4.98	5.13	5.03	4.75	4.79	4.47	4.75
Surgical rate in the age group 60+ years	57.99	59.05	55.35	53.83	50.46	47.18	46.02	44.00	42.69	39.23

Incidence and surgical rates are given per 100 000 inhabitants.

*On the European population.

Table 4 Incidence and number of deep sclerectomies performed in France from 2005 to 2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Crude incidence	5.08	10.07	9.77	9.90	9.08	8.99	8.85	8.86	8.40	8.12
Standardised incidence*	3.70	7.50	7.19	7.36	6.59	6.45	6.39	6.38	5.91	5.68
Surgical rate in the age group 0–14 years	0.19	0.49	0.48	0.43	0.50	0.66	0.56	0.58	0.39	0.25
Surgical rate in the age group 15–59 years	1.46	3.17	2.96	3.32	2.68	2.61	2.68	2.60	2.36	2.45
Surgical rate in the age group 60+ years	20.09	38.68	37.17	36.09	33.35	32.42	31.15	30.92	29.25	27.55

Incidence and surgical rates are given per 100 000 inhabitants.

*On the European population.

Table 5 Incidence and number of aqueous drainage procedures performed in France from 2005 to 2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Crude incidence per year	0.23	0.48	0.52	0.60	0.53	0.56	0.76	0.75	0.85	0.97
Surgical rate in the age group 0–14 years	0.07	0.09	0.16	0.14	0.08	0.08	0.54	0.44	1.01	1.37
Surgical rate in the 15–59 years	0.08	0.25	0.31	0.39	0.24	0.28	0.36	0.39	0.32	0.29
Surgical rate in the age group 60+ years	0.82	1.51	1.44	1.59	1.67	1.68	1.94	1.89	2.00	2.29

Incidence and surgical rates are given per 100 000 inhabitants.

Table 6 Incidence and number of ciliary body destructions performed in France from 2005 to 2014

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Crude incidence per year	1.91	2.16	2.25	2.54	1.98	1.95	1.89	2.03	2.39	3.14
Surgical rate in the age group 0–14 years	0.45	0.45	0.41	0.48	0.53	0.48	0.44	0.36	0.41	0.42
Surgical rate in the age group 15–59 years	1.11	1.15	1.19	1.37	1.05	1.09	0.96	1.08	1.33	1.69
Surgical rate in the age group 60+ years	5.55	6.63	6.86	7.49	5.70	5.37	5.42	5.68	6.48	8.67

Incidence and surgical rates are given per 100 000 inhabitants.

The trends of these operating room-based glaucoma procedures are displayed in [figure 1](#).

DISCUSSION

When analysing the complete data set of operating room-based glaucoma procedures in France, we found a sustained decrease in the rate of trabeculectomies while the number of other procedures increased during the 2005–2014 study period. However, trabeculectomy was the most commonly performed glaucoma surgery in France during this 10-year period. This is in agreement with a recent study reporting that trabeculectomy was the most frequently performed glaucoma surgery in 21 countries.¹³ Ciliary body destruction gained more acceptance among French ophthalmologists with a 73% increase over this observation period. In fact, cyclocryotherapy has been replaced by diode laser cyclophotocoagulation in France. Other techniques such as

endocyclophotocoagulation are rarely performed, probably because of the cost of the material and the issue of probe sterilisation. High-intensity focused ultrasound is a new cyclocoagulation technique available in France and has been on the market since 2014.¹⁴ Due to the cost of the device, the number of procedures performed so far with this technique is limited. A noticeable increase was also observed for aqueous shunts, although the total number remains very low compared with trabeculectomy or deep sclerectomy. These overall trends are very similar to those reported recently in Scotland, England and Wales,¹⁵ in Australia¹⁶ and in the USA.¹⁷

It has already been mentioned that reporting glaucoma surgical procedures is not an easy task.¹³ In fact, each country has its own particularities for delivering glaucoma surgical care and there is a high discrepancy in glaucoma surgical rates in different parts of the world.¹⁵ A recent survey reported an overall

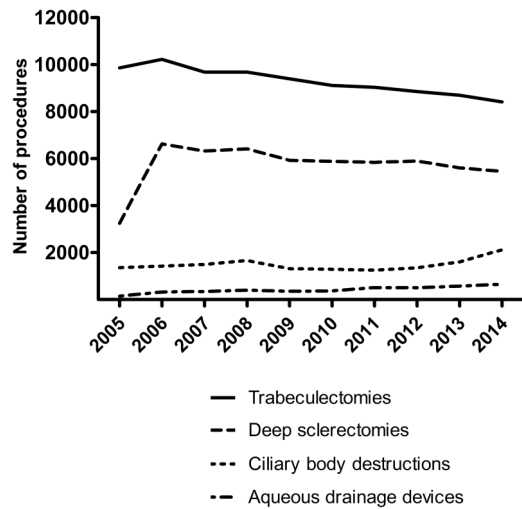


Figure 1 Trends of operating room-based glaucoma procedures in France from 2005 to 2014.

glaucoma surgery rate (GSR) ranging from 7 to 500, given per million inhabitants.¹³ This huge difference may account for different treatment modalities available in a given region, the level of reimbursement for patients and may depend on the number of ophthalmologists in a given area. In this study, we observed a positive association between the number of operating room-based glaucoma procedures and the number of ophthalmologists only for the country's 14 regions, in agreement with a recent report.¹³ Even though all ophthalmologists do not perform surgery, at least in France, non-surgical colleagues refer their patients with glaucoma to glaucoma surgeons when a surgical procedure is needed. The methodology used could also influence the results. For instance, for trabeculectomies, the GSR was higher in France than in three regions of the UK when considering the crude incidence (table 3).¹⁵ However, when taking into account a standardised incidence, the difference for GSR between these two studies was much lower. Therefore, investigators should come to an agreement on how to report the GSR consistently, so that countries can be compared more easily.¹³ Another difference between countries lies in the types of surgery delivered to patients. For instance, deep sclerectomy is not very popular in the UK, as has recently been reported.¹⁵ However, in other countries such as Switzerland, Italy, Spain and South American countries, non-penetrating surgery has gained more popularity. Deep sclerectomy accounted for 64.7% of the number of trabeculectomies in France in 2014. When we consider aqueous drainage devices in France, even though we noted an increase during the study period, they are representing in 2014 a small part of the operating room-based glaucoma procedures, 3.4%. This is in contrast with the findings of Canadian colleagues in Ontario where the aqueous drainage procedures jumped from 0.9% in 1992 to 33% in 2012 of the glaucoma filtration procedures.¹⁸

Overall, the number of glaucoma surgeries was much lower than the number of cataract surgeries. We have recently reported that for 2014 the number of phacoemulsification cataract extractions performed in France was 757 993, a 59.2% increase compared with 2005.⁹ Therefore, in 2014 the number of glaucoma procedures was only 2.2% of the cataract surgeries performed in the same year. Since both cataract and glaucoma are age-related diseases, a higher rate of glaucoma surgery could be expected. Indeed, it has been estimated that about 20% of the

patients operated for cataract have concomitant glaucoma.¹⁹ Even though only a fraction of these patients with glaucoma need glaucoma surgery, we could expect a higher number of operating room-based glaucoma procedures. This gap could be related to the decreasing number of glaucoma surgeons, as was reported for Canada.²⁰ In this study, we observed a similar trend, but since this information was available for the last 3 years of the study period, we cannot draw a definite conclusion. The complications of trabeculectomy may also refrain doctors from proposing a combined surgery with glaucoma at the time of cataract extraction.²⁰ Even though we do not yet have robust series showing the good risk-benefit profile for new glaucoma techniques such as minimally invasive glaucoma surgery (MIGS), it is true that a safer glaucoma surgery could lead eye doctors to propose a combined surgery to their patients with glaucoma more often.²¹ Finally, the debate on the effectiveness of combined surgery for glaucoma remains controversial. It is generally reported that a combined surgery is less effective in lowering IOP than a glaucoma surgery alone.²² In this study, even though the number of combined trabeculectomies and deep sclerectomies has decreased over time, it still accounts for about one-third of these two main glaucoma surgeries in France.

It is well documented that ethnicity is a risk factor for open-angle glaucoma.¹² Interestingly, we found that the GSR was higher in the French Indies than in Metropolitan France. The population of the French Indies (Guadeloupe and Martinique) is mainly of African descent and shares the similarities of the other Caribbean islands for glaucoma prevalence.²³ However, our findings should be taken with caution since many individuals born in the French Indies live in other departments in mainland France.

The strengths of this study are the use of big data, which allowed us to examine the entire population in France. We took into consideration a limited age range,¹⁷ and all age groups, as has already been reported.¹⁵ We acknowledge several limitations to this study. First, billing codes are given by surgeons and are subject to errors.¹⁷ However, since these national data are used for healthcare facilities, budget allocation encourages improvement in data quality in terms of coherence, accuracy and exhaustiveness. Nevertheless, the results collected in 2005 are probably not complete since it was the first year the fee-for-service model had been implemented, corresponding to a defined fee for a given surgical procedure paid to the healthcare facility. Second, due to the coding system, the number of available variables is limited. For instance, we do not know the eye side, which limits assessing whether two or more procedures were performed on one eye or on both eyes.¹⁷ These limitations are common to other countries as well; for instance, in a recent American report, it was not possible to determine the number of combined glaucoma and cataract surgeries.¹⁷ Third, the codes related to a surgical procedure are limited in France and do not describe exactly what has been done. For instance, we do not yet have a specific code for MIGS devices, which are gaining popularity in other countries.¹⁷ When coded, they are registered as an aqueous humour drainage procedure (code BEJB004), but it is impossible with our national database (PMSI) to distinguish between MIGS and more classical techniques such as Baerveldt or Ahmed tubes. Fifth, as has already been reported in the literature, we voluntarily focused on the main procedures needing access to the operating room, excluding from the study treatments performed at the consultation such as laser trabeculoplasty.²⁰ Therefore, we only considered both surgical procedures and laser therapy (cyclocoagulation)

requiring an operating-room environment with local anaesthesia.

In conclusion, using big data allowed us to provide a realistic account of the number, the incidence and the trend in glaucoma surgeries in France over a 10-year period.

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