Effect of Medical Therapy on Glaucoma Filtration Surgery Rates in Ontario

Rony Rachmiel, MD; Graham E. Trope, MB, PhD, FRCSC; Mary L. Chipman, MA; Pieter Gouws, MD, FRCOphth; Yvonne M. Buys, MD, FRCSC

Objective: To analyze trends of glaucoma filtration surgery in Ontario.

Methods: From April 1, 1992, through March 31, 2004, correlations were examined between the annual rates of trabeculectomies in Ontario, the use of glaucoma medications, and the numbers of practicing ophthalmologists and optometrists.

Results: The number of trabeculectomies per 1000 persons at risk for primary open-angle glaucoma increased from 33.5 in 1992 to 46.2 in 1996 (37.7% increase; 6.6% increase per year) and then steadily decreased to 38.2 in 2004 (17.0% decrease; 2.7% decrease per year). The number of glaucoma medications dispensed in Ontario increased from 766,000 in 1992 to 1,466,543 in 2004 (91.5% increase; 10.5% annual increase). The increase in dispensed prostaglandin analogues strongly correlated (P<.001; 95% confidence interval, −0.87 to −0.41) with the decreasing number of trabeculectomies. The decreasing number of ophthalmologists positively correlated (r=0.87) with the filtration surgery rate after 1997.

Conclusions: The number of trabeculectomies has decreased substantially in Ontario coinciding with the introduction of medications for the treatment of glaucoma in December 1996. This decrease in trabeculectomies highly correlated with the introduction of prostaglandin analogues (P<.001) and the decreasing number of ophthalmologists from 1997 through 2004.

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number of bottles dispensed in each category per year. The combination therapies were classified as follows: Combigan (0.2% brimonidine tartrate and 0.3% timolol maleate) as an $\alpha_2$-agonist, Cosopt (dorzolamide hydrochloride and 0.3% timolol maleate) as a topical CAI, Timpilo (2% or 4% pilocarpine hydrochloride and 0.5% timolol maleate) as a parasympathomimetic, and Xalacom (0.003% latanoprost and 0.5% timolol maleate) as a prostaglandin analogue. The number of ophthalmologists and optometrists in Ontario per year from 1992 through 2004 was obtained from the Ontario Medical Association and the Ontario Association of Optometrists.

Statistical analyses included regression analysis, with filtration surgery rate as the outcome variable, and Pearson correlation matrix between pairs of variables. The variables considered were filtration surgery rate, time in years, and total number of glaucoma medications dispensed overall and within each new medication group. One bottle of any of the medications was 1 month’s supply. Other variables considered were number of ophthalmologists and optometrists. The filtration surgery rates were used as the outcome variable.

The $t$ statistic used to calculate confidence intervals (CIs) is based on 12 years of data, but the percentage of drugs dispensed for each of the new drugs is zero before 1996. This fact will distort the estimated regression coefficients for year and percentage of total drugs because the regression assumed a straight-line relationship.

### RESULTS

The total number of trabeculectomies increased from 1735 in 1992 to 2647 in 1997 (52.6% increase) and then remained stable for the remainder of the study (Figure 1). During this time, the population in Ontario increased from 10,257,047 in 1992 to 12,246,600 in 2004 (19.4% increase; 1.5% increase per year). For those aged 40 years and older, the population increased from 4,136,704 in 1992 to 5,556,600 in 2004 (34.3% increase; 2.7% increase per year). The estimated prevalence of POAG increased from 51,727 (0.5% of the total population and 1.25% of the population older than 40 years) in 1992 to 69,154 (0.57% of total population and 1.25% of the population older than 40 years) in 2004 (33.7% increase; 2.4% increase per year). The number of trabeculectomies per 1000 individuals at risk for POAG increased from 33.5 in 1992 to 46.2 in 1996 (37.7% increase; 6.6% increase per year) and then steadily decreased to 38.2 in 2004 (17.0% decrease; 2.7% decrease per year) (Figure 2).

New medications for the treatment of glaucoma were introduced in Ontario as follows: dorzolamide hydrochloride, May 1996; 0.005% latanoprost, June 1997; 0.2% brimonidine tartrate, November 1997; Cosopt, May 1999; travaprost, November 2001; bimatoprost, May 2002; Xalacom, October 2002; and Combigan, December 2003. The total number of prescriptions for glaucoma medications dispensed in Ontario increased from 766,000 in 1992 to 1,466,543 in 2004 (91.5% increase; 10.5% increase per year) (Figure 3). For 1992 and 1996, $\beta$-blockers represented the greatest market share (59.5% and 52.7%, respectively) followed by parasympathomimetics (24.8% and 28.2%, respectively) and, to a lesser extent, sympathomimetics and oral CAIs. In 1997, the new glaucoma medications, topical CAIs and prostaglandins, represented 16.2% of dispensed glaucoma medications. In 1998, with the introduction of $\alpha_2$-agonists, the new antiglaucoma medications accounted for 26.9% of dispensed glaucoma therapy. In 2004, $\alpha_2$-agonists accounted for 64.3% of the dispensed glaucoma medications in Ontario.

The highest increase occurred in the prostaglandin analogue category, and specifically with latanoprost, which increased from 12,000 bottles when introduced in 1997 to 529,600 bottles in 2004, a 44-fold increase (Figure 4). In 1998, latanoprost accounted for 5.7% of the total number of glaucoma medications dispensed and increased to 36.1% in 2004.
The data were analyzed for correlations between time in years, filtration surgery rates, cataract surgery rates, total medications dispensed, and each new medication group (Table 1). There was a high positive correlation between time in years and the increasing number of total medications dispensed and each new medication group. There was a nonsignificant (P = .88) negative correlation between filtration surgery rates and total medications dispensed (r = −0.05). However, when each group was evaluated separately, there was a stronger, although not significant, negative correlation between filtration surgery rates and dispensed prostaglandins (r = −0.35; P = .27). The correlation for α2-agonists was −0.23 and for topical CAIs, 0.06, which were also not significant. The total glaucoma medications dispensed rate had a higher positive correlation with every new medication group.

Regression analysis (Table 2) indicated no evidence of an association between the filtration surgery rate and the number of glaucoma medications dispensed before 1997 (P = .23; 95% CI, −0.002 to −0.006). There was a slight trend between filtration rate and time in years (P = .07; 95% CI, −0.74 to 10.37). There was no evidence of an association between filtration surgery rate and the number of glaucoma medications dispensed after 1997 (P = .25; 95% CI, −3.25 to 1.12 and P = .87; 95% CI, −0.001 to 0.0031, respectively).

Regression models were used to examine the association of specific drug classes as a percentage of total medications dispensed, controlling for overall drug dispensed rate and year (Table 3). We found a strong relationship between the decreasing number of trabeculectomies and the increasing dispensed rate of prostaglandin analogues (b = −0.63; P < .001; 95% CI, −0.87 to −0.40). There was no evidence of association between the decreasing number of trabeculectomies and the rates for CAI (b = 0.41; P = .31; 95% CI, −0.47 to 1.31) and for α2-agonists (b = −0.87; P = .19; 95% CI, −2.28 to 0.53). The number of ophthalmologists in Ontario varied little during this time, increasing from 409 in 1992 to 431 in 1997 (5.4% increase) and then decreasing to 419 in 2004 (2.9% decrease). Despite this increase and decrease, the number of ophthalmologists per million population per year is strongly associated (r = 0.87) with the filtration surgery rate and strongly negatively associated with the total number of medications dispensed (r = −0.99) after 1997 (Table 1).

The number of optometrists practicing in Ontario has varied more, increasing from 857 in 1992 to 1365 in 2004 (59.3% increase; 4.0% increase per year). The number of optometrists per million population per year is negatively associated (r = −0.93) with the filtration surgery rate and associated with the total number of medications dispensed (r = 0.94) after 1997 (Table 1).

There has been a substantial decrease in the number of trabeculectomies in Ontario coinciding with the introduction of medications for the treatment of glaucoma in December 1996. This change highly correlated with the introduction of prostaglandin analogues and the decreasing number of ophthalmologists from 1997 through 2004. Previous publications of the trends in glaucoma surgery showed a 15% to 73% decrease in the number of glaucoma surgical procedures across various periods from 1994 through 2003. The medical system in Canada is government funded and managed provincially. Virtually all residents have a provincial health care card that must be presented to receive medical services funded by the provinces; therefore, there is an accurate registry of all surgical procedures performed on Canadian residents.
We found that the total number of trabeculectomies in Ontario increased by 52.6% from 1992 through 1997 and then remained stable for the remainder of the study (Figure 1). We calculated the estimated population at risk of having glaucoma in Ontario by using a composite POAG prevalence curve. When we corrected for changes in the population, we found that the number of trabeculectomies per 1000 individuals at risk for POAG increased by 37.7% from 1992 to 1996 and then steadily decreased by 17.0% to 2004 (2.7% decrease per year), similar to the trends indicated in other studies.

When changes are observed in the volume of a given surgical procedure, multiple factors are potentially responsible, including changes in disease management, accessibility to operating room time, reimbursement rates, incidence and prevalence of a disease, and changes in patient and physician perceptions regarding treatment options. Paikal et al proposed that the introduction of brimonidine and latanoprost could affect the rate of trabeculectomies and trabeculoplasties performed. In Scotland, Bateman et al found an increase of 24.9% in prescribed glaucoma medications per 1000 individuals at risk for POAG increased by 37.7% from 1992 to 1996 and then steadily decreased by 17.0% to 2004 (2.7% decrease per year), similar to the trends indicated in other studies.

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Table 2. Regression Analyses for Filtration Surgery Rates, Year, and Total Prescriptions Dispensed of Glaucoma Medications

<table>
<thead>
<tr>
<th>Regression Model</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t Statistic</th>
<th>P Value</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>4.82</td>
<td>1.74</td>
<td>2.76</td>
<td>.07</td>
<td>−0.74 to 10.37</td>
</tr>
<tr>
<td>Drugs per million population</td>
<td>−0.005</td>
<td>0.003</td>
<td>−1.50</td>
<td>.23</td>
<td>−0.005 to 0.01</td>
</tr>
<tr>
<td>Year</td>
<td>−1.06</td>
<td>0.79</td>
<td>−1.35</td>
<td>.25</td>
<td>−3.25 to 1.12</td>
</tr>
<tr>
<td>Drugs per million population</td>
<td>−0.0002</td>
<td>0.001</td>
<td>−0.17</td>
<td>.87</td>
<td>−0.01 to 0.01</td>
</tr>
</tbody>
</table>

Table 3. Regression Analyses for the Association Between Specific Drug Groups and Filtrations Surgery Rate, Controlling for Year and Total Drugs Dispensed

<table>
<thead>
<tr>
<th>Regression Model</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t Statistic</th>
<th>P Value</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>3.87</td>
<td>0.83</td>
<td>4.65</td>
<td>.002</td>
<td>1.95 to 5.80</td>
</tr>
<tr>
<td>Drugs per million population</td>
<td>−0.003</td>
<td>0.001</td>
<td>−2.36</td>
<td>.03</td>
<td>−0.005 to −0.001</td>
</tr>
<tr>
<td>Percentage that are prostaglandin analogues</td>
<td>−0.63</td>
<td>0.10</td>
<td>−6.33</td>
<td>&lt;.0001</td>
<td>−0.87 to −0.40</td>
</tr>
<tr>
<td>Year</td>
<td>1.98</td>
<td>1.76</td>
<td>1.13</td>
<td>.29</td>
<td>−2.07 to 6.04</td>
</tr>
<tr>
<td>Drugs per million population</td>
<td>−0.004</td>
<td>0.003</td>
<td>−1.40</td>
<td>.20</td>
<td>−0.01 to 0.002</td>
</tr>
<tr>
<td>Percentage that are carbonic anhydrase inhibitors</td>
<td>0.41</td>
<td>0.38</td>
<td>1.08</td>
<td>.31</td>
<td>−0.47 to 1.31</td>
</tr>
<tr>
<td>Year</td>
<td>0.35</td>
<td>1.89</td>
<td>0.19</td>
<td>.88</td>
<td>−4.01 to 4.71</td>
</tr>
<tr>
<td>Drugs per million population</td>
<td>0.001</td>
<td>0.003</td>
<td>0.39</td>
<td>.71</td>
<td>−0.007 to 0.01</td>
</tr>
<tr>
<td>Percentage that are α2-agonists</td>
<td>−0.87</td>
<td>0.61</td>
<td>−1.43</td>
<td>.19</td>
<td>−2.28 to 0.53</td>
</tr>
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We found that the total number of trabeculectomies in Ontario increased by 52.6% from 1992 through 1997 and then remained stable for the remainder of the study (Figure 1). We calculated the estimated population at risk of having glaucoma in Ontario by using a composite POAG prevalence curve. When we corrected for changes in the population, we found that the number of trabeculectomies per 1000 individuals at risk for POAG increased by 37.7% from 1992 to 1996 and then steadily decreased by 17.0% to 2004 (2.7% decrease per year), similar to the trends indicated in other studies.

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in 1992 to 109.4 in 2003 (69.3% increase; 6.0% increase population with cataract in Ontario increased from 64.6 to 2004. Filtration procedures in Ontario are reim-

more complicated when we used regression analysis to see if the supply of ophthalmologists was associated with the relation between trabeculectomies and the proportion of prostaglandin analogues among the drugs used after 1997.

We found a strong correlation between the decreasing number of trabeculectomies and the increase in medications dispensed. These analyses look at the role of the changing percentage of the total medications dispensed attributable to each of the 3 classes of new glaucoma medications, controlling for year and total medications dispensed. Only the model including prostaglandins was strongly significant (P<.001; 95% CI, −0.87 to −0.40). However, be-
cause the increase in prostaglandins was large (44 times), this result, although statistically significant, may not have been due to a cause-and-effect relationship.

In contrast to the number of trabeculectomies, the annual number of cataract surgical procedures per 1000 population with cataract in Ontario increased from 64.6 in 1992 to 109.4 in 2003 (69.3% increase; 6.0% increase per year). These data suggest that economic influences of the health system such as possible decreased access to operating room facilities cannot be responsible for the trends found for trabeculectomies.

Paikal et al14 and Strutton and Walt23 included economic influences or changes in disease management (other than those related to the new medications) as factors that may influence the glaucoma surgery trend. They showed that the changes in reimbursement rates in the US Medicare population were not responsible for the decrease in glaucoma surgical procedures in this population.

In Ontario, the reimbursement rates for cataract and filtration surgery did not dramatically change from 1992 to 2004. Filtration procedures in Ontario are reimbursed at approximately 70% of the rate for cataract surgery. The surgical time is longer than that of cataract surgery and there is a more demanding postoperative schedule, which may have some influence on the rates, although this is hard to prove.

Strutton and Walt23 suggested other explanations for the reduction in glaucoma surgical procedures: changes in disease incidence or prevalence and the possibility that the individuals who needed the procedures received them and this trend is simply the supply diminishing across time. In our study, using the census data14 to estimate the prevalence of POAG, we found an increase of 33.7% in the number of individuals at risk for POAG. Therefore, we should expect to have an increase in the number of surgical procedures. The sig-

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Correspondence: Rony Rachmiel, MD, Toronto Western Hospital, New East Wing, 399 Bathurst St, 6-403, Toronto, Ontario, Canada M5T 2S8 (rachmiel_r@hotmail.com).

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