



Influencing factors of hospitalization costs for glaucoma patients under clinical pathway management

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Background: To investigate and analyze the hospitalization costs of inpatients with primary acute angle closure glaucoma (PACG), and to explore the influencing factors of hospitalization cost and to provide reference for specialized hospitals to carry out clinical pathways.

Methods: The first page diagnostic data of PACG patients' medical records were collected, and an Excel database was established according to the International Classification of Diseases (ICD-10) code. Statistical analysis of hospitalization data was performed using SPSS 17.0 software.

Results: Hospitalization days and clinical pathway which affect the change of the hospitalization cost ($P < 0.001$).

Conclusions: Hospitalization day is an important factor affecting the hospitalization cost, reducing unnecessary hospitalization time can control the increase of hospitalization cost.

Keywords: Clinical pathway; glaucoma; hospitalization cost; statistical analysis

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Introduction

The clinical pathway is a strict sequential and time-based medical plan made by medical experts using diagnostic methods or operation method, the plan includes managements of diagnosis, examination, surgical methods, medical materials, medicine, nursing, etc. (1). In this study, the hospitalization data of primary acute angle closure glaucoma (PACG) patients entering the clinical pathway were statistically analyzed to understand their general situation, and to explore the changes of hospitalization cost before and after implementation of the clinical pathway. This study is to analyze the data of leading ophthalmic hospitals in China, and it can provide a good reference value for clinical pathways of similar hospitals in China.

Methods

Study subjects

The study subjects were patients diagnosed as PACG from January 1st, 2009 to May 31st, 2016 in an ophthalmic hospital. The subjects were divided into non-path group (January 2009–April 2010) and path group (May 2010–May 2016). According to the International Classification of Diseases (ICD-10), we screened effective data, collected the basic conditions of the patients' gender, age, hospitalization days, etc., and summed up the individual hospitalization expenses of the patients, such as medicine charges, examination fees, medical treatment fees, and total hospitalization expenses.

Inclusion criteria

Patients firstly diagnosed as PACG and those who underwent trabeculectomy and monocular surgery were included. The path can be entered when the patients had other disease diagnoses at the same time, but they didn't require special treatment during hospitalization or affect the implementation of the clinical pathway procedure for the first diagnosis.

Elimination criteria

Key variables missing, such as: admission, discharge time, various cost details, etc.; those who had surgical complications (poor wound healing, anterior chamber formation delay) and needed surgery, did not enter the path; those firstly diagnosed as PACG, combined with senile cataract, and needed to perform bluish and white combined surgery, did not enter the path; those with general anesthesia or local anesthesia combined with analgesic surgery, did not enter the path; those combined with systemic disease, and needed to continue treatment during hospitalization, did not enter the path; the simultaneous onset of both eyes was excluded.

Statistical analysis

This study used SPSS 17.0 analysis software to perform statistical analysis for patients' hospitalization data. General descriptions of basic characteristics, cost composition, standard deviation, and composition ratio of patients were carried out; hospitalization expenses under different time and different hospitalization factors was analyzed using rank sum test to compare cost differences; we used multiple stepwise regression to screen important factors.

Quality control

After reviewing a large number of relevant research literatures, we summarized the experience of similar research in the past, and combined the actual situation, after completing the collection of the original materials, we input the original records of each case into Excel 2003, reviewed and collated the collected data, before data analysis we made the necessary adjustments for those missing data to make the results more realistic. Finally the database was established and was performed using SPSS analysis software.

Results

Demographic and clinical characteristics analysis

A total of 415 patients were included in this study, including the path group (n=305) and the non-path group (n=110). The median number of hospitalization days for PACG patients in the path group was 5 days (maximum 14 days, minimum 1 day), and the non-path group was 7 days (maximum 19 days, minimum 3 days), which was longer than patients in the path group. The proportion of female subjects was higher than that of males, and the proportion of patients aged over 61 was the highest; the proportion of patients in Guangzhou and other cities in Guangdong Province was very high, and that in other provinces was lower. In terms of payment methods, most of them were at their own expense, followed by medical insurance and other payment methods, and the proportion of public funds was the least.

Comparison of hospitalization costs in PACG patients of two groups

After the inspection fee had been tested for normality, it conformed to the normal distribution, so more effective parametric test (*t*-test) was used instead of the non-parametric test; other expenses were partial distribution, and the two groups were compared using Wilcoxon rank sum test through continuous variable data. There was no significant difference in the cost of examination between the path group and the non-path group ($t=0.445$, $P=0.561$); other costs such as medicine, inspection, and diagnostic expenses were all statistically significant between the two groups ($P=0.005$). See *Table 1* for details.

Multiple linear regression analysis of hospitalization cost

Because the total cost of hospitalization was partial distribution, the logarithmic transformation (the e-based logarithm \ln for hospitalization expenses) was used to standardize the variables and transform the nonlinear relationship. Therefore, the variables were normalized, and the nonlinear relationship was transformed into a linear relationship. The probability of introduction and rejection were ≤ 0.05 and ≥ 0.10 respectively, and multiple linear regression analysis was used to analyze the multi-factor influencing factors. Because all patients in this study were treated with a uniform procedure (trabeculectomy), the analysis results of the factors affecting the cost of surgery showed no significant difference. See *Table 2* for details of

Table 1 Comparison on hospitalization costs and its main composition in PACG patients of two groups

Hospitalization costs & composition	Path group (n=305)		Non-path group (n=110)		Z	P
	M (min, max)	Q	M (min, max)	Q		
Total	5,952.85 (1,570.73, 8,775.15)	1,223.48	5,467.25 (3,733.13, 9,188.00)	778.23	5.139	<0.001
Medicine charge	437.59 (62.38, 2,524.43)	271.53	499.98 (178.43, 1,638.15)	220.07	2.803	0.005
Examination fee	1,366 (0.00, 2,889.00)	569.00	1,322.00 (368.00, 2,389.00)	418.75	0.582	0.561
Inspection fee	442 (0.00, 591.00)	512.00	303.96 (0.00, 382.20)	116.80	5.323	<0.001
Diagnosis	259 (32.50, 883.50)	222.50	212.5 (114.00, 664.00)	73.25	3.636	<0.001
Surgery	2,995 (15.00, 4,445.00)	1,008.00	2,788 (1,873.00, 4,514.00)	493.00	4.147	<0.001
Bed	238 (0.00, 1,318.88)	239.01	189 (88.00, 510.00)	84.00	4.454	<0.001
Other expense	185.57 (0.00, 546.89)	227.87	193.28 (181.23, 516.68)	93.68	4.453	<0.001

PACG, primary acute angle closure glaucoma.

Table 2 Variables and their assignments included in the regression model

Variables	Assignments
Gender	Male =1, female =2
Age	21–40 years =1, 41–60 years =2, >61 years =3
Hospitalization days	1–5 years =1, 6–10 years =2, 11–15 years =3, >16 years =4
Payment mode	Medical insurance =(0, 0, 0), public expense =(0, 0, 1), self-paying =(0, 1, 0), others =(1, 0, 0)
Admission condition	Normal =1, acute =2
Readmission in a month	Y =1, N =2
Path or non-path	Non-path =1, path =2

variables and their assignments.

Multiple linear regression analysis of factors affecting total hospitalization cost

The influencing factors of the total hospitalization cost of PACG patients were hospitalization days ($P<0.001$), rehospitalization ($P=0.002$), and path or non-path ($P<0.001$). The patients firstly admitted to hospital and those with more hospitalization days had more hospitalization costs. Compared with non-path group patients, the total hospitalization cost of patients in the path group was much more, which may be related to their more comprehensive diagnosis and treatment after implementation of path management. See *Table 3*.

Multiple linear regression analysis of factors affecting medicine expenses

The influencing factors of PACG patients' medicine fees were hospitalization days ($P=0.006$) and payment methods (self-pay *vs.* medical insurance, $P=0.043$). The

patients firstly admitted to hospital and those with more hospitalization days had more medicine costs. The self-pay patients spent more on medicine than patients covered by medical care insurance. See *Table 4* for details.

Multiple linear regression analysis of factors influencing examination costs

The factors influencing the inspection cost of PACG patients were hospitalization days ($P<0.001$), rehospitalization ($P<0.001$), and path or non-path ($P=0.009$). The patients firstly admitted to hospital and those with more hospitalization days had more examination costs. Patients in the path group had to afford more examination expenses than patients in the non-path group. See *Table 5* for more details.

Multiple linear regression analysis of factors influencing inspection costs

The factors influencing the inspection cost were hospitalization days ($P=0.014$), rehospitalization ($P<0.001$),

Table 3 Multiple linear regression analysis of factors affecting total hospitalization cost in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	0.016	0.017	0.045	0.958	0.339
Age	0.014	0.014	0.046	0.992	0.322
Hospitalization days	0.023	0.004	0.353	6.673	<0.001
Payment mode					
Medical insurance	Reference				
Public expense	0.031	0.078	0.072	0.394	0.694
Self-paying	0.022	0.076	0.067	0.292	0.770
Others	0.066	0.078	0.162	0.851	0.395
Admission condition	0.011	0.088	0.006	0.127	0.899
Readmission or not	0.148	0.047	0.147	3.176	0.002
Path or not	0.104	0.019	0.286	5.494	<0.001

PACG, primary acute angle closure glaucoma.

Table 4 Multiple linear regression analysis of factors affecting medicine expenses in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	0.009	0.057	0.008	0.164	0.870
Age	-0.019	0.047	-0.019	-0.395	0.693
Hospitalization days	0.033	0.012	0.153	2.767	0.006
Payment mode					
Medical insurance	Reference				
Public expense	0.517	0.267	0.368	1.940	0.053
Self-paying	0.527	0.26	0.483	2.025	0.043
Others	0.381	0.265	0.286	1.437	0.152
Admission condition	0.214	0.299	0.034	0.714	0.476
Readmission or not	0.044	0.159	0.014	0.279	0.780
Path or not	-0.067	0.065	-0.056	-1.033	0.302

PACG, primary acute angle closure glaucoma.

and path or non-path ($P<0.001$). The patients firstly admitted to hospital and those with more hospitalization days had more inspection costs. Patients in the path group had to afford more inspection costs than patients in the non-path group. See *Table 6* for more details.

Multiple linear regression analysis of factors influencing the cost of diagnosis and treatment

The influencing factors of diagnosis and treatment expenses

were hospitalization days ($P<0.001$), payment methods (public expenses *vs.* medical insurance, $P=0.020$; self-pay *vs.* medical insurance, $P=0.012$), rehospitalization ($P=0.021$), and path or non-path ($P<0.001$). The patients firstly admitted to hospital and those with more hospitalization days had more diagnosis and treatment costs. Patients in the path group had to afford more diagnosis and treatment costs than patients in the non-path group. Compared with the patients covered by medical insurance, the public and self-paying patients spent less on

Table 5 Multiple linear regression analysis of factors influencing examination costs in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	0.023	0.041	0.026	0.56	0.576
Age	0.038	0.034	0.052	1.145	0.253
Hospitalization days	0.070	0.008	0.431	8.337	<0.001
Payment mode					
Medical insurance	Reference				
Public expense	-0.112	0.189	-0.105	-0.593	0.553
Self-paying	-0.157	0.184	-0.190	-0.853	0.394
Others	-0.087	0.188	-0.086	-0.463	0.644
Admission condition	0.022	0.212	0.005	0.102	0.919
Readmission or not	0.535	0.112	0.216	4.766	<0.001
Path or not	0.121	0.046	0.134	2.631	0.009

PACG, primary acute angle closure glaucoma.

Table 6 Multiple linear regression analysis of factors influencing inspection costs in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	-0.081	0.098	-0.045	-0.831	0.407
Age	-0.029	0.078	-0.021	-0.376	0.707
Hospitalization days	0.049	0.020	0.147	2.463	0.014
Payment mode					
Medical insurance	Reference				
Public expense	-0.314	0.375	-0.163	-0.838	0.403
Self-paying	-0.240	0.365	-0.150	-0.658	0.511
Others	-0.439	0.378	-0.204	-1.164	0.245
Admission condition	-0.072	0.419	-0.009	-0.172	0.863
Readmission or not	2.452	0.421	0.317	5.829	<0.001
Path or not	0.434	0.105	0.255	4.117	<0.001

PACG, primary acute angle closure glaucoma.

diagnosis and treatment. See *Table 7*.

Multiple linear regression analysis of factors affecting bed fees

The influencing factors of bed fees for PACG patients were hospitalization days ($P<0.001$), payment methods (public expenses *vs.* medical insurance, $P=0.008$; other *vs.* medical insurance, $P<0.001$) and path or non-path ($P<0.001$). The

more hospital stays would cause more bed fee. Compared to medical insurance, public fees and other patients spent more on bed service. Patients in the path group had more bed costs than patients in the non-path group. See *Table 8*.

Multiple linear regression analysis on influencing factors of other cost

The influencing factors of other costs in PACG patients

Table 7 Multiple linear regression analysis of factors influencing diagnosis & treatment cost in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	-0.001	0.050	-0.001	-0.029	0.977
Age	0.019	0.041	0.021	0.453	0.651
Hospitalization days	0.085	0.010	0.419	8.152	<0.001
Payment mode					
Medical insurance	Reference				
Public expense	-0.542	0.233	-0.411	-2.329	0.020
Self-paying	-0.575	0.227	-0.563	-2.533	0.012
Others	-0.212	0.232	-0.169	-0.914	0.361
Admission condition	-0.339	0.261	-0.058	-1.296	0.196
Readmission or not	0.320	0.138	0.104	2.311	0.021
Path or not	0.265	0.057	0.237	4.686	<0.001

PACG, primary acute angle closure glaucoma.

Table 8 Multiple linear regression analysis of factors affecting bed fees in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	-0.009	0.058	-0.007	-0.156	0.876
Age	0.011	0.048	0.010	0.226	0.822
Hospitalization days	0.057	0.012	0.236	4.749	<0.001
Payment mode					
Medical insurance	Reference				
Public expense	0.738	0.277	0.467	2.664	0.008
Self-paying	0.519	0.270	0.423	1.920	0.055
Others	1.137	0.275	0.758	4.136	<0.001
Admission condition	-0.294	0.303	-0.042	-0.969	0.333
Readmission or not	-0.125	0.161	-0.034	-0.780	0.436
Path or not	0.240	0.066	0.179	3.649	<0.001

PACG, primary acute angle closure glaucoma.

were hospitalization days ($P=0.027$), payment methods (public expenses *vs.* medical insurance, $P=0.001$; self-paying *vs.* medical insurance, $P<0.001$; other *vs.* medical insurance, $P=0.019$) and admission status ($P=0.013$). The more hospital stays would cause more other costs. Compared with medical insurance, the public and self-paying had more other expenses, while patients with other payment methods spent less on other expenses. See *Table 9*.

Discussion

Whether there is a path management is a factor affecting hospitalization expenses, patients with clinical path management, except for medicine and other expenses, their total hospitalization expenses, examination fees, inspection fees, medical treatment fees, and bed fees were higher than those without clinical path management. In

Table 9 Multiple linear regression analysis of factors affecting other costs in PACG patients

Variables	Partial regression coefficient	SE	Standardized partial regression coefficient	t	P
Gender	0.150	0.096	0.065	1.565	0.119
Age	-0.005	0.078	-0.002	-0.059	0.953
Hospitalization days	0.044	0.020	0.097	2.230	0.027
Payment mode					
Medical insurance	Reference				
Public expense	1.625	0.507	0.645	3.208	0.001
Self-paying	1.835	0.500	0.799	3.671	<0.001
Others	-1.251	0.532	-0.277	-2.352	0.019
Admission condition	1.031	0.412	0.104	2.503	0.013
Readmission or not	0.361	0.270	0.055	1.336	0.183
Path or not	-0.132	0.095	-0.064	-1.386	0.167

PACG, primary acute angle closure glaucoma.

this study, the gender and age of the patients were not the influencing factors of hospitalization expenses, and different payment methods had an impact on the patients' medicine expenses, diagnosis and treatment expenses, bed fees and other expenses. Due to the different payment methods affecting medical behaviors and habits, medical institutions have different requirements for medical services. These differences are mainly reflected in the scope of medication, the payment limit for medical treatment, and the medication limits for medical insurance.

The hospitalization day was a common influencing factor for hospitalization costs in both groups, as reported in the literature (2-4). The average hospitalization day of the path group was 5 days, which was in line with the requirements of the clinical pathway program standard hospitalization day (7-12 days), and slightly lower than the average hospitalization day (7-9 days) in developed countries, which was consistent with domestic research (5,6). After the implementation of the path management, the average hospitalization day was shortened by 2 days. The clinical pathway was effective in shortening the hospitalization days, reflecting the improvement of hospital work efficiency, improvement of process management, and improvement of the collaboration level between clinical departments and medical technology examination departments.

In addition to the cost of surgery, the length of hospital stay had an impact on the total cost of hospitalization, medication, examination, inspection, medical treatment,

and other expenses. The patients with more hospitalization days had more expenses. Shortening the hospitalization days is of great significance to both patients and hospitals. However, because of the hospitalization days not being normal distribution, there will be factors such as individual differences, diagnosis and treatment level and efficiency causing some patients to have longer hospitalization days. The data of PACG patients in this study was from the first page of the medical record, with their diagnosis and treatment confirmed to be clear and effective. Overall, under the standard treatment of the clinical pathway, the possibility of lengthening the hospital stay due to over-examination or treatment was low. The extension of hospitalization days should be considered from the following two aspects: firstly, the patients' individual factors led to an increase in hospital stays; secondly, the overall efficiency of the hospital will also lead to an increase in hospitalization days.

In addition to the length of hospital stay and the path management, rehospitalization is also a factor in the hospitalization expenses of PACG patients. The first-admitted patients had more hospitalization cost than those who were re-admitted. The main reasons were as follows: firstly, the cost of examination fees and inspection fees for re-admitted patients were reduced, resulting in more hospitalization cost for the first admission patients than those with re-admission; secondly, due to the limitation of current standard for medical insurance, patients normally

chose to have two separate hospitalizations for the surgery of two eyes.

In the non-path group, the first-admitted PACG patients or those with more hospitalization days had more hospitalization costs, which was the same as the path group. Cases in the path group were standardized according to the clinical path treatment plan. The program made corresponding provisions for the indications such as surgical methods, medication use, examination items, and hospitalization time. Because of not long enough clinical path implementation and the imperfect diagnosis and treatment process, some doctors might not grasp the strict use of medicine and inspection indications. The implementation of clinical pathway therapy may limit the reform and innovation of clinical thought and technical ability, which may also be related to the inherent profit motives of public hospitals under the existing health care system (7). As a result, some doctors did not strictly implement the medical treatment process, and still used medicine and treatment according to the past practice.

Statistical analysis on glaucoma, age and gender composition showed that the incidence of PACG was closely related to age. The proportion of PACG patients aged ≥ 41 years was 98% in the path group and 97.3% in the non-path group, which was similar with domestic research results (97.11%) (8). It may be related to the structural features of Asian eyes. With the increase of age, the anterior chamber becoming shallower, the narrower angle of the anterior chamber, the thicker lens, advances, and the emotional fluctuation of women during menopause, the risk of PACG incidence would be induced to increase (9,10). The ratios of male to female in PACG patients were 1:2.43 for the path group and 1:3.4 for the non-path group. The acute PACG patients in two groups were mostly female, similar to the data (1.49) reported by Lin *et al.* (11), suggesting that PACG patients are still mostly female, and gender is a very important factor in the occurrence of PACG.

The distribution of patients before and after the implementation of the clinical pathway did not change much. During the 7-year period, the patients were mainly from Guangdong Province (Guangzhou and other cities in the province), which was related to the hospital's being located in Guangzhou and it's forming a stable patient distribution range. Regional distribution relationship. Hospital administrators should make relevant glaucoma prevention and publicity work and post-operative follow-up survey according to the source of the patient area. In 2015, Guangdong Province launched a provincial cross-

region medical insurance settlement platform to collect capital and information flow to achieve rapid settlement in the province. Patients covered by medical insurance can be confirmed when they are discharged from the hospital. They only need to pay their individual expenses to complete the discharge. The development of domestic informatization has changed the cross-region medical treatment mode, and will definitely change the choice of diagnosis treatment for cross-region medical insurance. In the future, the distribution of PACG patients' regions will also be changed due to changes in payment methods.

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study is a retrospective analysis, the patients' privacy is strictly protected, we only collect the data for secondary use, there is no ethical issue. Informed consent was waived due to the retrospective nature of the study.

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