Relationship between hospital volume and risk-adjusted mortality rate following percutaneous coronary intervention in Korea, 2003 to 2004

2003 ve 2004 yılları arasında Kore'de perkütan koroner girişim sonrası hastane hacmi ve risk-ayarlı mortalite arasındaki ilişki

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ABSTRACT

Objective: There have been a large number of studies that have investigated the relationship between outcomes and provider volume for a wide variety of medical conditions and surgical conditions. The objective of this study was to explore the relation between hospital volume and risk-adjusted mortality following percutaneous coronary intervention between 2003 and 2004 in Korea.

Methods: This is a retrospective analysis of database in National Health Insurance Review & Assessment Service and Korean National Statistical Office. The study data set confined to the ICD-10 diagnosis and procedure codes that were recorded in the National Health Insurance Review Agency. Risk modeling was performed through logistic regression and validated with cross-validation. The statistical performance of the developed model was evaluated using c-statistics, R^2, and Hosmer-Lemeshow statistic. Crude and risk-adjusted 30-day mortality was evaluated among patients who underwent Percutaneous Coronary Intervention (PCI) between 2003 and 2004 at low (less 200 cases/year), medium (200~399 cases/year), and high (400 cases or more/year) PCI volume hospitals.

Results: The final risk-adjustment model consisted of ten risk factors for 30-day mortality. These factors were found to have statistically significant effects on patient mortality. The c-statistic and Hosmer-Lemeshow χ^2 goodness-of-fit test and the model's performance were good [R^2=0.147, c-statistic 0.823, 4.1037 (p=0.8476)]. A total number of 60 low-volume hospitals (9.071 patients) and 27 medium-volume hospitals (15.623 patients) and 15 high-volume hospitals (19.669 patients) were included. Crude 30-day mortality rate was 1.4%, 1.1%, and 1.0% (p=0.0106) in each volume hospitals. But risk-adjusted mortality rate was not significantly different among three groups (1.3%, 1.0%, and 1.1% in each volume hospitals).

Conclusion: Although we found a significant different crude 30-day mortality rates according to hospital PCI volume, but did not find a relationship between hospital volume and 30-day risk-adjusted mortality rates following PCI in Korea. *(Anadolu Kardiyol Derg 2013; 13: 237-42)*

Key words: Percutaneous coronary intervention, volume, outcome, risk-adjustment, mortality, regression analysis

ÖZET

Amaç: Çok değişik tıbbi ve cerrahi durumlar için, hizmet sağlayanın volümü ile sonuçlar arasındaki ilişkiyi araştıran pek çok çalışma vardır. Bu çalışmanın amacı, 2003 ve 2004 yılları arasında Kore'de perkütan koroner girişim sonrası hastane hacmi ve risk-ayarlı mortalite arasındaki ilişkiyi ortaya çıkarmaktı.

Yöntemler: Bu çalışma Ulusal Sağlık Sigorta İnceleme ve Değerlendirme Servisi ve Kore Ulusal İstatistik Ofisi veritabanının retrospektif bir analizidir. Çalışmanın verileri Ulusal Sağlık Sigorta İnceleme Ajansı'nda kaydedilmiş ICD-10 tanı ve işlem kodlarını kapsar. Risk modelleme lojistik regresyon yoluyla yapıldı ve çapraz-doğrulama ile doğrulandı. Geliştirilen modelin istatistiksel performansı c-istatistikleri, R^2, ve Hosmer-Lemeshow istatistiği kullanılarak değerlendirildi. Basit ve riske ayarlı 30 günlük mortalite, Perkütan Koroner Müdahale (PKM) yapılan hastalar

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Accepted Date/Kabul Tarihi: 31.10.2012 **Available Online Date/Çevrimiçi Yayın Tarihi:** 06.02.2013

doi:10.5152/akd.2013.070

Anadolu Kardiyol Derg
2013; 13: 237-42

2003 ve 2004 yılları arasında, düşük (200'den az olgu/yıl), orta (200~399 olgu / yıl) ve yüksek (400 olgularda veya fazla/yıl) PKM hacimli hastanelerde değerlendirildi.
Bulgular: Son risk düzeltme modeli 30-günlük mortalite için on risk faktöründen oluşuyordu. Bu faktörlerin, hasta mortalitesi üzerine anlamlı etkilerinin olduğu saptandı. C-istatistik ve Hosmer-Lemeshow χ^2 ``goodness-of-fit`` testi ve modelin performansı iyiydi [R^2=0.147, c-statistic 0.823, 4.1037 (p=0.8476)]. Altmış düşük-hacimli hastanenin (9.071 hasta) ve 27 orta-hacimli hastanenin (15.623 hasta) ve 15 yüksek-hacimli hastanenin (19.669 hasta) toplam sayısı dahil edildi. Basit 30-günlük mortalite oranı her bir hastane volüme için sıra ile %1.4, %1.1 ve her birimin hastanelerde oranı %1.0 (p=0.0106) idi. Buna karşılık, risk ayarlı ölüm oranı üç grup arasında anlamlı değildi (%1.3, %1.0, ve %1.1; her bir hastane volümü için).
Sonuç: Kore'de hastane PCI hacmine göre, basit 30-günlük mortalite oranlarında önemli farklılık bulmamıza rağmen PKG sonrası 30 günlük risk-ayarlı ölüm oranları ile hastane hacmi arasında bir ilişki bulamadık. *(Anadolu Kardiyol Derg 2013; 13: 237-42)*
Anahtar kelimeler: Perkütan koroner girişim, hacim, sonuç, risk-ayarlı, ölüm, regresyon analizi

Introduction

In general, it is believed that technically challenging manual procedures will result in a better outcome if it is performed by skilled specialists at high-volume institutions. Previous studies also have demonstrated above suggestions in many surgical procedures, such as coronary artery bypass graft, pancreatic and thoracic surgery (1-3). In cardiology, the relationship between hospital percutaneous coronary intervention (PCI) volume and in-hospital mortality has been widely investigated (4, 5). There is some evidence that the disparity in outcomes of PCI between high-and low-volume hospitals has narrowed over time (6). But a recent meta-analysis reported this relationship has not attenuated over time (7). Most of the studies related with hospital volume and outcome originated from USA hospitals. The number of studies from outside the USA was too small to explore the similarity of the effect across countries. Only a couple of studies originated from Japan (8-10). In addition, it is unclear whether previous results can be generalized to other countries outside the USA. So we tried to evaluate the relationship between hospital volume and risk-adjusted mortality rate following PCI in Korea.

Methods

Database

We analyzed data from the Korea National Health Insurance Review & Assessment Service and Korean National Statistical Office between 2003 and 2004 for this study. We used American Agency for Healthcare Research and Quality (AHRQ) for guidance of our study (11). So we defined general patient information and all the International Statistical Classification of Diseases, Tenth Revision (ICD-10) diagnosis and procedure codes. In the present study, PCI patients were defined as the ones who were diagnosed with such codes as M6551, M6552, M6561, M6562, M6563, M6564, M6571, and M6572. We excluded patients under the age of 18 and neonatal or obstetric admissions in order to restrict our evaluation to the use of PCI in a typical adult population. We consulted with five expert interventional cardiologists working in university hospitals to reduce selection bias of risk factors.

Hospital PCI volume groups

To assess the validity of the annual hospital PCI volume threshold of 400 cases recommended by ACC/AHA PCI guidelines (12) and by the Leapfrog Group (13) we divided above data into three groups. Hospitals with fewer than 400 annual cases were divided into those below 200 cases (hereafter referred to as low-volume) and 200 to 399 cases (medium-volume). Hospitals with above 400 annual cases were classified as high-volume hospitals.

Definition of death

Major cardiac adverse events frequently occurred within one month of PCI so we investigated 30 day mortality rates (14) and we compared the deceased patient's biological information with data from the Korean National Statistical Office. We included only patients expired in hospital and excluded expired out of hospital or unidentified death in our analysis.

Variables for analysis

Patient characteristics such as admission source (referral, emergency medical services or others), admission type (outpatient or emergency room) and presence of diabetes mellitus, hypertension, hyperlipidemia, congestive heart failure (CHF), cardiogenic shock, arrhythmia, chronic obstructive lung disease (COPD), renal disease, peripheral vascular disease, stroke, multivessel procedure, stent deployment and the type of coronary artery disease (stable angina, unstable angina, myocardial infarction) were analyzed.

Statistical analysis

The SAS 9.1 statistical software (SAS Institute Inc., Cary, NC, USA) was used to perform the statistical analysis of the data. Patients biological, admission and comorbidity information were compared across the three hospital PCI volume groups using global chi-square analyses for categorical variables and risk-adjustment model. We performed univariate logistic regression analysis to evaluate risk factors that influence 30-day mortality. Those variables that were significant predictors on univariate analysis were entered into the multivariate logistic regression model. We calculated adjusted mortality rate and compared relationship between severity determining risk factors and hospital volume. The statistical performance of the developed model was evaluated using C-statistics, R^2, and Hosmer-Lemeshow statistic.

$$\text{Adjusted Mortality Rate} = \frac{\text{Actual Number of Deaths}}{\text{Predicted Number of Deaths}} \times \text{Overall Mortality Rate}$$

Odds ratios with 95% confidence intervals were calculated for each covariate. Statistical significance was defined as p values <0.05.

Results

Our analysis involved 44.363 patients. The mean age of the patient population was 63.8 years. 64.9 % were men and 35.1% were women. Clinical characteristics and variables included in our study are presented in Table 1. There were 102 hospitals performing PCI during the study period. A total of 60, 27 and 15 hospitals were in low, medium and high-volume hospital groups. 9.071 (20.5%) patients were treated at high-volume hospitals, 15.623 (35.2%) at medium-volume hospital and 19.669 (44.3%) at low-volume hospital. Mean age, admission type, diabetes, hypertension, hyperlipidemia, unstable angina, acute myocardial infarction (AMI), congestive heart failure (CHF), arrhythmia, chronic obstructive lung disease (COPD), renal disease, peripheral vascular disease, stroke, multivessel procedure and stent deployment to be significant predictors for 30-day mortality (Table 2). These significant risk factors entered into the multivariate logistic regression analysis. The logistic-regression model revealed age, emergency visitors, AMI, CHF, arrhythmia, COPD, renal disease, stroke, multivessel procedure and stent deployment to be significant predictors (Table 3). Hosmer-Lemeshow χ^2 goodness-of-fit test showed a p value of 0.8476 and good-model quality. The Cochran-Armitage trend test (p=0.0106) showed crude 30-day mortality rates declined with increasing volume and rates were 1.4% in low, 1.1% in medium and 1.0% in high volume hospitals, p<0.05. When we considered crude 30-day mortality rates patients treated at low-volume hospitals had significantly higher mortality rates than those treated in medium-volume (1.4% vs. 1.1%, p<0.05) or high-volume hospitals (1.4% vs. 1.0%, p<0.05). But we could not find any relationship between hospital volume and 30-day risk-adjusted mortality rates (1.3% in low, 1.0% in medium and 1.1% in high volume hospitals) following PCI in Korea (Table 4).

Discussion

The use of administrative data to identify inpatient complications is technically feasible and inexpensive but unproven as a quality measure. Weingart et al. (15) suggested that screening administrative data may offer an efficient approach for identifying potentially problematic cases for physician review.

Table 1. Patient's characteristics

Variables	No. of patients	%
Sex		
Male	28.787	64.9
Female	15.576	35.1
Age, years*	63.8±10.2	
40~50	4.521	10.2
51~60	9.947	22.4
61~70	16.240	36.6
≥70	13.655	30.8
Admission source		
Referral	3.736	8.4
Emergency medical services	1.268	2.9
Others	39.336	88.7
Admission type		
Emergency room	17.617	39.7
Outpatient	26.723	60.3
Diabetes mellitus	7.116	16.8
Hypertension	20.952	47.2
Hyperlipidemia	4.542	10.2
Coronary artery disease		
Stable	2.035	4.6
Unstable	18.970	42.8
AMI	20.468	46.1
CHF	3.187	7.2
Cardiogenic shock	367	0.8
Arrhythmia	1.898	4.3
COPD	729	1.6
Renal disease	1.166	2.6
Peripheral vascular disease	1.519	3.4
Stroke	2.583	5.8
Multivessel procedure	210	0.5
Stent employed	27.008	60.9
Total	44.363	-

Data are presented as mean±SD, number and percentage
AMI – acute myocardial infarction, CHF – congestive heart failure, COPD – chronic obstructive pulmonary disease

Sundararajan et al. (16) said ICD-10 Charlson comorbidity coding algorithm had a good to excellent discrimination in their ability to predict mortality. So we used ICD-10 diagnosis and procedure codes. During the past 20 years researchers have focused on measuring and explaining the association between patient outcomes and the volume of health services provided by hospitals and physicians (17). Mant studies have documented that higher volume is associated with better outcomes. They suggested this results may be because physicians develop more

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Table 2. Comparison of risk factors in 30-day mortality

Risk Factors		Live, n (%)	Death, n (%)	*p
No. of patients		43.872 (98.9)	491 (1.1)	-
Sex	Male	28.502 (99.1)	285 (0.9)	0.0014
	Female	15.370 (98.7)	206 (1.3)	
Mean age±SD		63.7±10.1	71.1±9.9	<.0001†
Admission source	Referral	3.708 (99.2)	28 (0.8)	0.0724
	EMS	1.251 (98.7)	17 (1.3)	
	Others	38.913 (98.8)	446 (1.2)	
Admission type	Emergency	17.313 (98.3)	304 (1.7)	<.0001
	Outpatient	26.559 (99.3)	187 (0.7)	
Diabetes	Yes	7.045 (94.3)	420 (5.6)	<.0001
	No	36.827 (99.8)	71 (0.2)	
Hypertension	Yes	20.778 (99.2)	174 (0.8)	<.0001
	No	23.094 (98.7)	317 (1.3)	
Hyperlipidemia	Yes	4.059 (89.4)	483 (10.6)	<.0001
	No	39.813 (99.9)	8 (0.1)	
Coronary artery disease				
Stable angina	Yes	2.023 (99.4)	12 (0.6)	0.0225
	No	41.849 (98.9)	479 (1.1)	
Unstable angina	Yes	18.892 (99.6)	78 (0.4)	<.0001
	No	24.980 (98.4)	4138 (1.6)	
AMI	Yes	20.045 (97.9)	423 (2.1)	<.0001
	No	23.827 (99.7)	68 (0.3)	
CHF	Yes	3.101 (97.3)	86 (2.7)	<.0001
	No	40.771 (99.0)	405 (1.0)	
Cardiogenic shock	Yes	363 (98.9)	4 (1.1)	0.1971††
	No	43.509 (98.9)	487 (1.1)	
Arrhythmia	Yes	1.829 (96.4)	69 (3.6)	<.0001
	No	42.043 (99.0)	422 (1.0)	
COPD	Yes	703 (96.4)	26 (3.6)	<.0001
	No	43.169 (98.9)	465 (1.1)	
Renal disease	Yes	1.142 (97.9)	24 (2.1)	0.0016
	No	42.730 (98.9)	467 (1.1)	
Peripheral vascular disease	Yes	1.493 (98.3)	26 (1.7)	0.0219
	No	42.379 (98.9)	465 (1.1)	
Stroke	Yes	2.531 (98.0)	52 (2.0)	<.0001
	No	41.341 (98.9)	439 (1.1)	
Multivessel procedure	Yes	193 (91.9)	17 (8.1)	<.0001††
	No	43.679 (99.0)	474 (1.0)	
Stent employed	Yes	26.544 (98.3)	464 (1.7)	<.0001
	No	17.328 (99.8)	27 (0.2)	

*Chi-square test
†Student's t-test
††Fisher's exact test
AMI - acute myocardial infarction, CHF - congestive heart failure, COPD - chronic obstructive pulmonary disease, EMS - emergency service

Table 3. Multiple logistic regression analysis for 30-day mortality

Variables	OR (95% CI)	p
Hospital PCI volume		
<200	1.530(1.170-2.025)	0.0082
200-399	1.325(1.011-1.554)	
>400	1.0	
Sex		
Male	1.0	0.1313
Female	0.988 (0.816-1.196)	
Age	1.068 (1.058-1.079)	<.0001
Admission type		
Outpatient	1.0	<.0001
Emergency	1.585 (1.313-1.915)	
AMI	4.093 (2.984-5.615)	<.0001
CHF	1.583 (1.239-2.023)	0.0002
Arrhythmia	2.481 (1.899-3.240)	<.0001
COPD	1.765 (1.162-2.682)	0.0078
Renal disease	1.740 (1.134-2.670)	0.0112
Peripheral vascular disease	1.170 (0.773-1.771)	0.4579
Stroke	1.415 (1.050-1.906)	0.0224
Multivessel procedure	4.870 (2.836-8.364)	<.0001
Stent employed	2.370 (1.470-3.821)	0.0004
R^2	0.147	
C - statistic	0.823	
Hosmer-Lemeshow χ^2 goodness-of-fit test (p value)	4.1037 (0.8476)	

AMI - acute myocardial infarction, CHF - congestive heart failure, CI - confidence interval, COPD - chronic obstructive pulmonary disease, OR - odds ratio, , PCI - percutaneous coronary intervention

effective skills if they treat more patients (practice makes perfect) and physicians and hospitals achieving better outcomes receive more referrals and thus accrue larger volumes (selective referral) (18, 19). That is patients treated at high-volume hospitals encounter a lower risk of mortality when compared with patients treated at low-volume hospitals. But Burton et al. (20) reported a result that 17, 417 PCIs performed in Scotland between 1997 and 2003 found no influence of the annual PCI volume of the participating hospitals on 30-day death rate. A Task Force of the German Society of Cardiology on quality assurance in invasive cardiology concluded that only a weak volume-outcome relation exists for contemporary PCI (21). Moscucci et al. (22) and Spaulding et al. (23) reinforced the volume-outcome relation with the limitation that it could be observed in high-risk patients. So there are some debates on volume-outcome result of PCI patients, especially from the cutoff point of annual PCI volume. In Korea, Korean Circulation Society started nationwide multicenter PCI registry since 2006. Before this year only one center registry data was valuable. So our volume-outcome relationship study is the first report in Korea. Although crude 30-day

Table 4. 30-day mortality rates of patients undergoing PCI at low-volume (<200 cases/year), medium-volume (200~399cases/year) and high-volume (>400 cases/year) hospitals

Variables	Low-volume hospitals	Medium-volume hospitals	High-volume hospitals	Total
No. of hospitals	60	27	15	102
No. of patients, n (%)	9.071 (20.5)	15.623 (35.2)	19.669 (44.3)	44.363 (100.0)
Total No. of patients deaths, n (%)	124 (25.3)	169 (34.4)	198 (40.3)	491 (100.0)
Crude mortality rates, %	1.4	1.1	1.0	1.1*
Risk-adjusted mortality rates, %	1.3	1.0	1.1	1.1**

mortality rates were significantly different among three groups [1.4%, 1.1%, and 1.0% (p=0.0106)], risk-adjusted mortality rates were not significantly different among these groups (1.3%, 1.0%, and 1.1% in each volume hospitals). The patients treated at hospitals that performed fewer than 200 PCI procedures annually may have a similar mortality rates in any other PCI volume group. Several concerns have been raised about attempts to assess the previous results be generalized to other countries outside the USA. Lin et al. (10) suggests that current ACC/AHA PCI hospital volume minimums may need to be reevaluated in non-Western countries such as Taiwan. Epstein et al. (4) suggested that there is narrowing difference in mortality rates between high-and medium-volume hospitals due to accumulating experience with PCI procedures among surgeons, especially those serving in medium-PCI volume hospitals. In our study, crude 30-day mortality rate was 1.1% (Table 2). Zahn et al. (24) reported an in-hospital mortality of 1.85% in hospitals belonging to the lowest PCI volume quartile and 1.21% in the highest quartile. But technological improvement of PCI, PCI instruments and new pharmacologic therapies in recent years it might have reduced mortality. We used risk-adjusted mortality rate in this study. This equation is composed of actual number of deaths, predicted number of deaths and overall mortality rate. The statistical performance of the developed model was evaluated using c-statistic, R^2, Hosmer-Lemeshow statistic. They showed good model quality. Future studies of the PCI volume-outcome association will need to determine the process through which volume and outcomes are linked and to identify recent year's trends.

Study limitations

Our analysis used ICD-10 diagnosis and procedure codes data, and thus may not had captured the full clinical detail of a patient's risk profile. In particular, no data regarding target coronary vessel characteristics, stent types, left ventricular ejection fraction or Killip class, type of arrhythmias, type of peripheral vascular disease, and use of antiplatelet agents were precisely recorded which makes the analysis incomplete. We evaluated in-hospital mortality alone and could not assess other patient's outcomes, including periprocedural complications, repeat revascularization rates, or longer-term outcomes. Another limitation is we did not track the experience of individual operators. So we cannot account for the influence of individual operator PCI volume on the association between hospital PCI volume and mortality. Although we had finely analyzed database of Korean National Statistical Office, we included only patients deceased in hospital and excluded deceased out of hospital or unidentified death in our analysis.

Conclusion

Although we could find significant relationship between different crude 30-day mortality rates according to hospital PCI volume, we could not find a relationship between hospital volume and 30-day risk-adjusted mortality rates following PCI in Korea.

Conflict of interest: None declared.

Peer-review: Externally peer-reviewed.

Authorship contributions: Concept - Y.H.K.; Design - A.Y.H.; Supervision - A.Y.H.; Resource - Y.H.K.; Materials - Y.H.K.; Data collection&/or Processing - A.Y.H.; Analysis &/or interpretation - Y.H.K.; Literature search - A.Y.H.; Writing - Y.H.K.; Critical review - A.Y.H.

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