Mortality following primary total knee replacement in public hospitals in Hong Kong

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A B S T R A C T

Introduction: More than 2000 total knee replacements are performed each year in Hong Kong and more than 10 000 patients are on the waiting list. How safe is total knee replacement, however? The aims of the study were to review the mortality of primary total knee replacement in public hospitals in Hong Kong and to identify risk factors for mortality in a high-volume hospital.

Methods: All primary total knee replacements performed in Hospital Authority hospitals and Yan Chai Hospital from October 2011 to September 2014 were reviewed. Case-control analysis was performed for risk factors of total all-cause mortality in total knee replacement at Yan Chai Hospital.

Results: There were 6588 patients in Hospital Authority hospitals and 1184 in Yan Chai Hospital (1095 unilateral and 89 bilateral total knee replacement). The mean follow-up time of patients in Yan Chai Hospital was 12.8 months. The mortality at 30 days, 90 days and 1 year was 0%, 0.08%, 0.34% for Yan Chai Hospital; and 0.1%, 0.2%, 0.7% for Hospital Authority hospitals, respectively. For Yan Chai Hospital, the mean operation-to-death interval was 21 months (range, 1-35 months). The mean age at death was 78 years and main causes were malignancy (50%) and pneumonia (21%). Predictors of mortality included age at surgery, American Society of Anesthesiologists class 3, and preoperative range of motion. Hospital surgery volume, preoperative co-morbidities, and postoperative deep vein thrombosis were not significant factors.

Conclusions: Mortality after primary total knee replacement was low in public hospitals in Hong Kong. Patients of older age or poorer general well-being in terms of poor range of motion or American Society of Anesthesiologists class 3 should be in optimal health before surgery and counselled about the higher mortality rate. A citywide joint replacement registry may help monitor and analyse postoperative total knee replacement mortality specific to our locality.

Hong Kong Med J 2016;22:237–41
DOI: 10.12809/hkmj154712

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This article was published on 6 May 2016 at www.hkmj.org.

New knowledge added by this study

- Preoperative range of motion may be predictive of mortality in primary total knee replacement.

Implications for clinical practice or policy

- Proper preoperative optimisation of general health and counselling is necessary before primary total knee replacement.

Introduction

More than 2000 primary total knee replacements (TKR) are performed in Hong Kong each year and more than 10 000 patients are on the waiting list for TKR at public hospitals. With an ever-increasing waiting list, joint replacement centres with high surgery volume have been set up in public hospitals. More such centres are planned in the future to tackle the ageing population and rising demand. As one of the most popular elective 'ultra-major' surgeries, how safe is primary TKR?

According to various knee replacement registries, 30-day mortality of TKR ranges from 0.2% to 0.4%, 90-day mortality 0.4% to 0.7%, and 1-year mortality 1% to 2%.[1-8] Risk factors for post-TKR mortality include age at operation, male sex, too high or low body mass index, American Society of Anesthesiologists (ASA) class 3 to 4, presence of co-morbidities, and simultaneous bilateral surgery.[1-4,6-12] There are a lack of similar data for the Asian population, however, and the risk of mortality in a high-volume hospital has not been described locally. The aims of the study were to review the mortality of primary TKR in Hong Kong and to identify risk factors of post-TKR mortality in a high-volume hospital.

香港公立醫院初次全膝關節置換術後的死亡率

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引言：香港每年有超過2000個全膝關節置換術，且超過10 000名患者在候診。然而，全膝關節置換術是否安全？本研究旨在審查在香港公立醫院初次全膝關節置換術後的死亡率，並找出在一所高手術量醫院中初次全膝關節置換術後死亡的危險因素。

方法：回顧分析於2011年10月至2014年9月期間所有在香港公立醫院和仁濟醫院接受初次全膝關節置換術的患者，並進一步利用病例對照研究分析仁濟醫院內初次全膝關節置換術的總全因死亡的危險因素。

結果：研究期間香港公立醫院共有6588名患者，仁濟醫院則有1184名患者（其中1095例屬單邊置換術，89例屬雙邊置換術）。仁濟醫院患者的平均跟進期為12.8個月，其30天、90天和1年死亡率分別為0%、0.08%和0.34%，香港公立醫院的則依次為0.1%、0.2%和0.7%。仁濟醫院患者的平均死亡時間為術後21個月（介乎1-35個月），平均死亡年齡為78歲，主要原因是惡性腫瘤（50%），其次為肺炎（21%）。死亡率的預測因素包括手術年齡、ASA 3級和術前關節活動度。醫院手術量、術前合併症和術後下肢深靜脈血栓均不是預測因素。

結論：香港公立醫院初次全膝關節置換術後的死亡率低。年齡較大或整體健康較差的患者（即關節活動度不佳或屬ASA 3級），醫生須確定病人術前的健康狀況良好才建議他們接受手術；病人亦應於術前理解此手術有較高死亡率。全民關節置換註冊表有助監測和分析初次全膝關節置換的術後死亡率。

Methods

Data retrieval

All primary TKR performed in public hospitals (Hospital Authority) and all primary TKR at the authors' institute (Yan Chai Hospital, YCH) from October 2011 to September 2014 were reviewed. Data retrieval for all public hospitals was performed with the Clinical Data Analysis and Reporting System. Procedure code for retrieval was "81.54 TOTAL KNEE REPLACEMENT". Data of patients at our institute were retrieved additionally with Clinical Management System of the Hospital Authority. The medical records of all deceased cases before September 2015 were reviewed.

Data analyses

The primary outcome measures were 30-day, 90-day, and 1-year mortality. Correlation coefficient between 30-day, 90-day, and 1-year mortality and annual surgery volume of all public hospitals was calculated with Pearson test. From data of YCH, comparisons were made between the mortality of unilateral TKR and simultaneous bilateral TKR. Case-control analysis was performed for possible risk factors of primary TKR total mortality. A control group included non-mortality cases of all simultaneous bilateral TKR in the same period and all unilateral primary TKR performed from October 2012 to March 2013. The latter period was chosen to allow a 1-year 'run-in' time for the newly established joint replacement centre that commenced operation in October 2011. All bilateral cases were used due to their relative scarcity. Chi squared test and Fisher's exact test were used for univariate analysis, and multiple logistic regression was used for multivariate analysis. Final model for multiple logistic regression was identified by backward elimination. A P value of <0.05 was considered statistically significant.

Results

There were 6588 primary TKR in 15 public hospitals and 1184 primary TKR at YCH (1095 unilateral and 89 bilateral). The 30-day, 90-day, and 1-year mortality was 0% (n=0), 0.08% (n=1), and 0.34% (n=4) for YCH and 0.1% (n=8), 0.2% (n=16), and 0.7% (n=48) for all public hospitals (YCH inclusive), respectively (Table 1). There was no correlation between hospital surgery volume and 30-day, 90-day, or 1-year mortality among the 15 public hospitals (R=0.151, P=0.578; R=0.031, P=0.910; R=0.032, P=0.972, respectively). For cases at YCH, the mean follow-up time was 12.8 (range, 4-38) months, the mean operation-to-death interval was 21 (1-35) months, and the mean age at death was 78 (70-87) years. Main causes of death were malignancy (50%) and pneumonia (21%) [Table 2]. Significant predictors of total mortality identified by univariate analysis included age at operation, preoperative range of motion (ROM), and ASA class 3; the former two were also confirmed by the final model of multivariable analysis (Table 3). The mean age at operation was 76 versus 68 years for mortality and non-mortality cases while the mean preoperative ROM was 95 versus 108 degrees, respectively. Body mass index, co-morbidities, deep vein thrombosis (DVT) prophylaxis, and postoperative DVT did not differ significantly between the two groups. Preoperative Western Ontario and McMaster Universities Arthritis Index (WOMAC), Knee Society score (KSS), and function score (FS) were also not significantly different. There was no significant difference in 30-day, 90-day, or 1-year mortality for bilateral TKR versus unilateral TKR (Table 1).

Discussion

Mortality rate

The 30-day, 90-day, and 1-year mortality in Hong Kong public hospitals was 0.1%, 0.2%, and 0.7%, respectively. These compared favourably with data of large national joint registries of other countries: 0.2% to 0.4%, 0.4% to 0.7%, and 1% to 2%, respectively.[1-8] There is no definitive explanation for such findings but several possibilities exist. First, TKR is still mostly considered a 'risky' and major operation in Hong Kong such that the popularity of such surgery

TABLE 1. Comparison of mortality rates

Mortality	YCH (n=1184)			HA, 2011-2014 (n=6588)	HK general population age-specific annual all-cause mortality rate at 2013[16]	
	Bilateral TKR (n=89)	Unilateral TKR (n=1095)	Total		Age 65-69 years	Age 70-74 years
30-Day	0% (n=0)	0% (n=0)	0% (n=0)	0.1% (n=8)	0.92%	1.65%
90-Day	0% (n=0)	0.09% (n=1)	0.08% (n=1)	0.2% (n=16)		
1-Year	0% (n=0)	0.37% (n=4)	0.34% (n=4)	0.7% (n=48)		

Abbreviations: HA = Hospital Authority; HK = Hong Kong; TKR = total knee replacements; YCH = Yan Chai Hospital

TABLE 2. Summary of mortality cases in Yan Chai Hospital from October 2011 to September 2014

Case No.	Surgery	Sex	ASA class	Pre-ROM (degrees)	Age at surgery (years)	Age at death (years)	Operation-to-death interval (months)	Cause of death
1	Unilateral TKR	Female	3	80	75	77	28	Pneumonia
2	Unilateral TKR	Female	2	95	72	74	14	Malignancy
3	Unilateral TKR	Male	1	95	75	75	10	Aspiration
4	Unilateral TKR	Female	1	100	73	74	15	Malignancy
5	Unilateral TKR	Female	2	80	75	79	35	Dissecting aortic aneurysm
6	Unilateral TKR	Male	3	110	71	74	31	Congestive heart failure, sepsis
7	Unilateral TKR	Female	3	100	68	70	17	Malignancy
8	Unilateral TKR	Female	2	75	79	82	24	Malignancy
9	Unilateral TKR	Male	3	105	85	87	31	Malignancy
10	Unilateral TKR	Female	3	125	75	78	27	Pneumonia
11	Bilateral TKR	Male	1	90	80	83	27	Malignancy
12	Unilateral TKR	Female	3	90	81	81	3.5	Pneumonia
13	Unilateral TKR	Female	2	65	81	81	1.2	Possibly AMI / CVA, not determined
14	Unilateral TKR	Female	2	120	79	80	11	Malignancy

Abbreviations: AMI = acute myocardial infarction; ASA = American Society of Anesthesiologists; CVA = cerebrovascular accident; Pre-ROM = preoperative range of motion; TKR = total knee replacement

remains low compared with other countries. In 2013, the incidence of primary TKR was around 4 per 10 000 population in Hong Kong (estimated from data of the present study) compared with 12 in the United Kingdom, 14 in Sweden, and 19 in Australia.[13-15] Lower operation incidence implies stricter selection criteria for operation. Second, the mortality of the general population of Hong Kong is known to be among the lowest in the world[16]; our findings may partly reflect the low mortality of the general population. Third, easy access to medical treatment in Hong Kong might facilitate timely intervention of early complications, hence reducing postoperative mortality. Whatever the explanation, the lower mortality indicates that primary TKR in Hong Kong are safe and conform to international standards.

One-year mortality following primary TKR in Hong Kong was lower than the mortality of the general population of the same age[16] (Table 1). Similar findings have been shown by other studies.[17] It has been suggested that strict selection criteria for operation meant that those selected were of better health than the general population. It was also hypothesised that pain relief and restored function would have a positive effect on a patient's overall health, hence a lower mortality in the long term. Nevertheless, 1-year may be too short a period for the latter effect to be obvious.

Mortality risk factors

In the present study, older age at operation was identified as a significant risk factor. This is consistent with findings in other studies.[2-4,6-9,11,18] Some studies have reported higher 30-day,[2-4] higher 90-day,[6,7] and even higher total mortality in the long term.[9,11] With an ageing population and higher life expectancy, there will be more patients with older age in future who undergo TKR. To date, there is no consensus on an age limit for the procedure. It is agreed that patients in their 80s or even 90s could still benefit from the surgery[18] provided the associated higher mortality is well explained and accepted.

The presence of co-morbidities was not a

TABLE 3. Predictors of all-cause mortality in patients with primary total knee replacement in Yan Chai Hospital*

	All-cause mortality cases (n=14)	Control (n=279)	P value (Chi squared / Fisher's exact tests)	P value (multiple logistic regression)	Odds ratio (95% CI)
Age (years)	76 ± 5	68 ± 8	<0.001†	0.057 / 0.01†	1.10 (1.00-1.22)
Sex (female)	71.4%	68.1%	1.000		
BMI (kg/m^2)	27.5 ± 2.5	27.6 ± 4.0	0.951		
Preoperative WOMAC	46 ± 16	53 ± 19	0.308		
Preoperative FS	44 ± 4	46 ± 11	0.490		
Preoperative KSS	43 ± 16	51 ± 14	0.055		
Preoperative ROM (degrees)	95 ± 17	108 ± 18	0.007†	0.005† / 0.001†	0.92 (0.87-0.98)
Co-morbidities	85.7%	89.6%	0.649		
ASA class 3	38.9%	19.3%	0.047†		
Anaesthesia (SA)	64.3%	49.2%	0.272		
OT time (mins)	97 ± 11	90 ± 18	0.180		
DVT prophylaxis	14.3%	21.5%	0.741		
Postoperative DVT	14.3%	23.5%	0.534		

Abbreviations: ASA = American Society of Anesthesiologists; BMI = body mass index; CI = confidence interval; DVT = deep vein thrombosis; FS = function score; KSS = Knee Society score; OT = operating; ROM = range of motion; SA = spinal anaesthesia; WOMAC = Western Ontario and McMaster Universities Arthritis Index

* Data are shown as mean ± standard deviation or percentages, unless otherwise specified

† P value of the final model with backward analysis

significant predictor of mortality in the present study. Rather, the poor control or the severity of co-morbidities in terms of ASA class 3 was found by univariate analysis to be a significant factor. There is evidence that patients with only specific co-morbidities such as cardiovascular disease will have higher mortality.[1,4,6-8,19] In addition, higher 30-day mortality,[3] 90-day mortality,[6] and total mortality[8,9] have been associated with higher ASA class. The lack of significance of ASA class 3 in multivariate analysis in our study suggests an underlying confounding factor. Analysis by *t* test showed that the age of patients with ASA class 3 was significantly older (72 vs 67 years, P<0.001). Thus in the present study, ASA class was confounded by age at surgery.

Preoperative ROM was also found to be a significant factor by univariate and multivariate analyses in the present study. This might be a novel finding. The exact explanation for such an association requires exploration by further study. One possibility is that preoperative ROM predicts postoperative ROM[20] that in turn affects postoperative ambulation and function. As mentioned above, it was hypothesised that restored ambulation and function can have a positive effect on a patient's overall health, hence a lower mortality. There are studies which reported an association between mortality and postoperative knee function. The latter was in terms of preoperative ambulatory status,[8] postoperative ambulatory status, and postoperative WOMAC pain score.[11] No knee score in the present study was found to be a significant predictor of mortality, however. One explanation could be that FS, WOMAC, and a large portion of KSS are patient-reported outcomes whereas ROM is an objective measurement; the more objective the measurement, the better it might be in predicting a secondary outcome such as mortality.

Although bilateral TKR has been found by several studies to have a higher mortality rate,[12,21,22] it was not a significant predictor in the present study. Our institute performed bilateral TKR in selected patients with mild and well-controlled co-morbidities and younger age. Also, the fast-track rehabilitation protocol was used with an average length of hospital stay of 9.6 days (authors' unpublished data). The results of analysis might reflect the equivalent safety of bilateral TKR with careful patient selection and fast-track rehabilitation. Many studies have demonstrated equal mortality for bilateral TKR with careful patient selection and a fast-track protocol.[23,24]

The present study has some limitations. First, due to inconsistent documentation across all public hospitals, data for case-control analysis for predictors of mortality were obtained from patients at our institute only. The smaller sample size limited the power of analysis of the present study. Second, since 70% of the mortality of our institute occurred more than 1 year after surgery and the mean operation-to-death interval was 21 months, analysis for predictors of mortality was performed on total mortality rather than 30-day, 90-day, or 1-year mortality. The very low early mortality in our institute and in Hong Kong means that a more powerful analysis of mortalities within 1 year may require a much larger sample size. This calls for a citywide joint replacement registry in which there is unified and detailed documentation of preoperative patient parameters, operative details,

and postoperative outcome measurements. Such registries have already been established nationwide for 11 years in the United Kingdom[13] and for 40 years in Sweden.[14] Third, data for other known significant predictors of all-cause mortality, such as smoking and alcoholism, were not analysed. These factors might have confounded the present study. Since these factors are not known to be associated with age or preoperative ROM, the influence of these potential confounders on the conclusion of the present study should be insignificant. Lastly, the period chosen for selection of the control group did not fully match the death cases. This may have introduced confounding factors or made the groups incomparable. Since there was no change in the indications for surgery, surgical practice or rehabilitation protocol during the study period, and the sampled control should be representative of the target population.

Conclusions

Mortality after primary TKR was low in public hospitals in Hong Kong. Patients of older age or poorer general health in terms of poor ROM or ASA class 3 should be in optimal health before surgery and counselled about the higher mortality rate. The role of a pre-admission clinic and fast-track rehabilitation in contributing to the lower mortality in our institute should be further explored. A citywide joint replacement registry may help monitor and analyse post-TKR mortality specific to our locality.

Declaration

All authors have disclosed no conflicts of interest.

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