

Clinical Outcomes Of Single Stage Posterior-Only Debridement And Instrumentation In The Management Of Spinal Tuberculosis

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**Dissertation Submitted In Partial Fulfilment Of The
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ABSTRAK

Pengenalan

Tuberkulosis (tibi) tulang belakang adalah jenis tibi paling kerap diantara golongan “selain tibi paru-paru”. Rawatan utama bagi tuberkulosis tulang belakang adalah dengan ubat “anti-tuberculois”. Walau bagaimanapun, rawatan dengan kaedah pembedahan adalah disyorkan untuk mengawal peningkatan *kyphosis* dan memperbaiki gangguan neurologi yang berkaitan dengan penyakit ini. Di antara pelbagai kaedah pembedahan yang disarankan, kaedah pembedahan melalui pendekatan posterior telah mendapat populariti kerana kadar komplikasinya yang dilaporkan rendah. Dalam kajian ini, kami melaporkan hasil klinikal kaedah pembedahan melalui pendekatan posterior tahap tunggal untuk debrimen dan instrumentasi bagi rawatan tibi tulang belakang.

Kaedah kajian

Dalam kajian retrospektif ini, kami menganalisis 27 pesakit tibi tulang belakang toraks-lumbar yang dirawat di pusat perubatan kami dari tahun 2003 hingga 2019 dengan kaedah pembedahan melalui pendekatan posteriortahap tunggal untuk debridement dan instrumentasi. Sudut *kyphosis*, penilaian neurologi ASIA, “protein C-reaktif” (CRP), kadar pemendapan eritrosit (ESR) dan skor skala analog visual (VAS) dibandingkan antara pra-operasi dan pasca-operasi. Pembetulan pada *kyphosis* termasuk kehilangan sudut *kyphosis*, pemulihan neurologi, penyembuhan jangkitan dan kelegaan kesakitan pada temu janji akhir dinilai. Data dianalisis menggunakan SPSS versi 24. Pemboleh ubah berangka disampaikan dalam bentuk purata dan sisihan piawai sementara pemboleh ubah kategori disampaikan sebagai frekuensi dan peratusan. Pemboleh ubah berangka dinilai menggunakan kekenyalan dan kurtosis.

Keputusan

15 pesakit lelaki dan 12 pesakit wanita dengan purata usia 51 tahun telah dirawat. Semua pesakit mempunyai tibi tulang belakang melibatkan dua segmen vertebra yang berterusan. Purata ESR pra-pembedahan ialah $74.78 \pm \text{SD } 23.68$ mm/h dan turun ke $25.46 \pm \text{SD } 19.49$ mm/h pada temu-janji akhir satu tahun. Purata CRP pra-pembedahan adalah 80.89 ± 50.26 mg/L dan telah kembali ke 16.55 ± 10.01 mg/L pada temu-janji akhir satu tahun. Terdapat penurunan VAS dari 6.96 ± 1.29 yang direkodkan sebelum pembedahan kepada 1.37 ± 0.57 pada temu-janji akhir satu tahun. Purata sudut *kyphosis* pra-pembedahan adalah $17.75^\circ \pm 10.49^\circ$ dan diperbetulkan sehingga $9.87^\circ \pm 7.47^\circ$ selepas pembedahan dengan purata pembetulan $7.88^\circ \pm 6.99^\circ$ (45.37%). Pada akhir satu tahun temu-janji, purata kehilangan sudut pembetulan adalah $2.22^\circ \pm 2.15^\circ$ (32.38%). Tidak ada pesakit yang mencatatkan kemerosotan neurologi dan 100% kadar pemulihan neurologi diperhatikan pada temu-janji satu tahun.

Kesimpulan

Hasil kajian ini menunjukkan perubahan positif dalam pembetulan *kyphosis*, pemulihan neurologi, skor VAS serta penyembuhan jangkitan.

Kata kunci: Tuberkulosis tulang belakang, pendekatan posterior, *kyphosis*

ABSTRACT

Introduction

Spinal tuberculosis is the most common form of extra-pulmonary tuberculosis. Anti-tuberculous chemotherapy has been the standard treatment for spinal TB. However, surgical management is recommended to control the progression of kyphosis and improve the neurological impairment associated with this disease. Various surgical methods have been advocated. But the posterior approach surgery has gained popularity due to its reported low complication rate. In this study, we report the clinical outcomes of single stage posterior only approach for debridement and instrumentation for treatment of spinal tuberculosis.

Methodology

In this retrospective study, we analysed 27 patients with thoraco-lumbar TB treated in our centre from 2003 to 2019 with single-stage posterior only debridement and instrumentation. Preoperative and postoperative kyphosis angle, ASIA neurological grading, C-reactive protein (CRP), erythrocyte sedimentation rate (ESR) and visual analog scale (VAS) score were compared. Correction in kyphosis including loss of kyphosis angle, neurological recovery, resolution of infection and pain relief at one year follow-up was assessed. The data was analysed using SPSS version 24. Numerical variables were presented as mean and standard deviation while categorical variables were presented as frequency and percentage. The numerical variables were assessed using skewness and kurtosis.

Results

15 male and 12 female patients with mean age of 51 years were treated. All patients had two contiguous vertebral segment involvement. The preoperative average rise in ESR was $74.78 \pm$ SD 23.68 mm/h which significantly dropped down to $25.46 \pm$ SD 19.49 mm/h at one year follow-up. The average preoperative rise in CRP was 80.89 ± 50.26 mg/L which returned to 16.55 ± 10.01 at one year follow-up. There was significant improvement of VAS from 6.96 ± 1.29 preoperatively to 1.37 ± 0.57 at one year follow-up. Preoperatively, the mean kyphosis angle was $17.75^\circ \pm 10.49^\circ$ and corrected postoperatively to $9.87^\circ \pm 7.47^\circ$ with an average correction of $7.88^\circ \pm 6.99^\circ$ (45.37%). At one year follow-up, the mean loss of correction was $2.22^\circ \pm 2.15^\circ$ (32.38%). No patients recorded any neurological deterioration with 100% neurological recovery observed at one year follow-up.

Conclusion

The results of this study show improvements in kyphotic correction, neurological recovery, VAS score as well as resolution of infection.

Key words: Spine tuberculosis, Posterior-only approach, kyphosis

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Tuberculosis (TB) is a communicable disease that is a leading cause of death worldwide. An estimated 10.0 million people contracted tuberculosis in 2019, a figure that has been steadily decreasing in recent years[1]. Spinal tuberculosis (TB) is the most common extra-pulmonary manifestation of TB, accounting for approximately 50% of bone and joint TB[2]. It is a serious spinal disease that frequently causes severe damage, such as kyphotic deformity, neurologic deficit, paralysis, and even death[3]. Anti-TB chemotherapy has become the mainstay of TB treatment and a vast majority of patients can be cured. However, conservative treatment has not been able to stop kyphotic deformity caused by spinal instability, and neurological recovery has been largely unsatisfactory. Furthermore, the anti-TB treatment requires long-term immobilization, and its effects are limited. Thus, surgery is recommended for spinal TB to halt the progression of kyphotic deformity, neurological deficit and pain. The ideal surgical approach for spinal TB is controversial. But, the posterior approach surgery has gained popularity among spine surgeons in recent times due to its reported low complication rate.

In this study, we report our clinical outcomes regarding the treatment of spinal tuberculosis by single stage posterior decompression and stabilization in selected patients.

1.2 OBJECTIVE

General Objectives

To evaluate the clinical and radiological outcomes of posterior-only debridement, decompression and instrumentation in the management of TB spine.

Specific Objectives

1. To assess the mean kyphotic correction that can be achieved via the posterior-only approach.
2. To evaluate the extent of pain recovery achieved via posterior-only approach using VAS score.
3. To evaluate the resolution of TB infection via serial ESR and CRP monitoring.
4. To evaluate the neurological recovery in patients treated by posterior-only approach.

CHAPTER 2: STUDY PROTOCOL

DISSERTATION PROPOSAL

TITLE:

**Clinical Outcomes Of Single Stage
Posterior-Only Debridement And
Instrumentation In The Management
Of Spinal Tuberculosis**

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Introduction

Tuberculosis (TB) remains the most common cause of death from infectious disease world-wide. Spinal tuberculosis (TB) is the most common extra-pulmonary manifestation of TB, accounting for approximately 50% of bone and joint TB and is one of the main pathologies seen in spinal and general orthopaedic units in the developing world [28]. Percival Pott described tuberculosis of the vertebral column in 1877 as a kyphotic deformity of the spine associated with paraplegia[16]. Spinal TB is a critical spinal disease that frequently causes severe damage, such as kyphotic deformity, neurologic deficit, paralysis, and even death. Although medical treatment has shown good response in spinal tuberculosis, it heals with an altered spinal alignment in advanced stage. The final collapse depends on the intervertebral site involvement (softening and destruction caused by disease) and the number of segments involved. Therefore, surgical treatment now forms an integral part of management not only in neurological deficit patients but also in patients who are potential to develop significant deformity as the disease progresses [18]. The principle of operative management is decompression of the spinal cord by surgical removal of granulation and necrotic tissue and drainage of any abscesses followed by immobilization of the spine. It also increases the vascularity, improves the drug delivery to the disease site, and thus helps in healing and bony fusion.

Problem statement & Study rationale

However controversies remain regarding the ideal surgical method. Since, TB spine being an anterior disease, anterior decompression and fixation has been considered as the gold standard. But it has problems of anaesthetic complications, higher morbidities, vascular injury, graft failure, and poor fixations in osteopenic bone. Sometimes even additional incision or surgery is required for posterior fixation. Hence, recently the posterior approach surgery has gained popularity, based on the principle of adequate but not extensive debridement and stable fixation, with much lower complication rates [1,12,23].

Spinal TB lesions are mainly concentrated in the anterior column, and the posterior-only approach for spinal TB remains controversial as whether it can completely achieve focal debridement, and whether reconstruction of spinal stability can be effectively obtained is poorly understood. The posterior approach has no advantages in terms of debridement, However under the precondition of standard anti-TB therapy, TB lesions may heal through spontaneous fusion, and complete debridement is not overly emphasized [29].

Therefore, in this study we would like to evaluate the outcomes of single stage posterior- only debridement, decompression and instrumentation in TB spine.

Literature review

Approach for surgical treatment of thoracolumbar tuberculosis has always been controversial. The aims of treating spinal tuberculosis are to eradicate the infection, prevent or treat neurological deficits, correct kyphosis deformities, and finally to achieve normal sagittal contours of the spinal column, unrestricted motility, and achieve full activities of daily living as soon as possible. Spinal tuberculosis can be treated surgically by anterior instrumented fusion, combined anterior-posterior procedure, extra-pleural anterolateral procedure or posterior procedures [4]. Tuberculosis almost always affects the anterior part of vertebral body, the disc and the adjacent vertebral bodies; therefore, the traditional and logical thinking had long been to use an anterior surgical approach to reach the spine to evacuate an abscess, excise the diseased tissues, decompress the neural tissues, and to insert a bone graft to correct kyphosis, achieve solid fusion and minimize disease recurrence.

Güven et.al who first proposed the posterior instrumentation with or without transpedicular abscess drainage in thoracolumbar spinal TB and found it to be effective in preventing kyphosis.

Gupta et.al has studied the functional and neurological outcome of the patients of thoracolumbar tuberculosis treated by a posterior only approach. Forty- One patients with thoracolumbar tuberculosis who underwent posterior approach in combination with debridement, interbody autografting and instrumentation were reviewed. He has concluded posterior instrumentation is considered superior to anterior instrumentation in correcting the kyphosis deformity of the thoracic and lumbar spine and in maintaining that correction. The probable reason for this might be that pedicle screws cross the vertebral body pedicle, the

strongest part of the vertebral body, providing three-dimensional correction and strengthening the spinal three-column stability, which is much stronger than anterior instrumentation. Though the anterior approach is the preferred method for debridement and decompression of the lesion, it is associated with an increased morbidity. The posterior approach allows a 270 degree view of the lesion for debridement and allows a reasonable decompression. Better functional outcome and better correction of the kyphotic angle are strong points favoring the use of posterior approach.

Sahoo et.al who evaluates the results of posterior decompression and transpedicular screw fixation in 18 cases of thoracolumbar spinal tuberculosis with neurological deficit obtained 94.4% of neurological recovery. She has concluded that the posterior- only approach for fixation and decompression of thoraco-lumbar tuberculosis as a safe procedure and effective method in relieving pain, correcting and preventing kyphosis, and improving neurological status in cases of Pott paraplegia involving thoracolumbar spines.

Research on the surgical management of Spinal Tuberculosis is still lacking in Malaysia. This study on clinical outcomes of single stage posterior-only debridement and instrumentation in the management of spinal tuberculosis will be the pioneer study in Malaysia to reveal the effectiveness of surgical intervention as part of management of spinal tuberculosis. This will be a good reference and a guide to the clinician especially orthopaedic surgeons in managing their patients.

Since this study is being conducted on our own local population, it will stand on its own in evaluating the outcomes of surgical treatment among Malaysian whose socio-economic and demographic status is differ from western or other Asian countries. Many patients who seeks

treatment for spinal tuberculosis at HUSM are mostly comes with late presentation as many seeks traditional treatment before coming to hospital. Another reason for them to present late is the poor access to the spine centre and the of course the worry on the success rate of operative intervention. Since HUSM is only performing posterior approach for the surgical treatment of spinal TB, we have vast experience in dealing with the complications of spinal Tuberculosis as well strong data to prove the operative outcomes. The result of this study will definitely change the public's perspective on spinal surgery performed on TB patients and create more confidence in them seeking surgical treatment for spinal tuberculosis in Malaysia as early intervention is crucial in arresting disease progress such as progressive kyphotic deformity and worsening neurological deficit.

Apart from this, the results of this study may elevate the name of HUSM as a renowned spine centre in the northern region of Malaysia and could attract more grants for advance research in Tuberculosis of spine as well more international collaboration for exchange of knowledge and technology

In conclusion, this single-stage posterior debridement, decompression, and instrumentation represent an effective approach to treat spinal tuberculosis with or without neurological deficits. The procedure causes less trauma, fewer complications, and has a more positive effect on kyphosis correction, achieves satisfactory neurological recovery, and spinal stability reconstruction.

Objective

General:

To evaluate the clinical and radiological outcomes of posterior-only debridement, decompression and instrumentation in the management of TB spine.

Specific:

1. To assess the mean kyphotic correction that can be achieved via the posterior-only approach.
2. To evaluate the extent of pain recovery achieved via posterior-only approach using VAS score

Since the introduction of “Pain As The 5th Vital Sign “ by Ministry of Health Malaysia in 2008, documentation of pain score has been routinely emphasised in doctor’s clerking as well on nursing observation chart. We believed that, pain score (either numerical rating scale or VAS) is well documented in patient’s clinical notes. However, in the event where there is no documentation of patient’s pain score, patients will be contacted via telephone to arrange for appointments to meet them. During the appointment, those patient will be required to recall the pain intensity prior to operation, anytime between 6/52 to 3/12 post-operative period and at 1 year follow-up. In a study conducted by Peter Salovey on a accuracy of memory for pain which was published in Journal of Pain in 1993, mentioned that self-reports of pain can generally be trusted and they appear to be recalled with reasonable accuracy and concluded that retrospective self-reports of pain collected systematically with measures of proven reliability seem relatively trustworthy.[24]

3. To evaluate the resolution of TB infection via serial ESR and CRP monitoring.
4. To evaluate the neurological recovery in patients treated by posterior-only approach.

Research design

Cross sectional non-interventional study

Study area

Orthopaedic spine unit, Department of Orthopaedic, Hospital Universiti Sains Malaysia

Study population

All patients whom have underwent operative treatment for TB spine via posterior-only debridement, decompression and instrumentation.

Subject criteria

All patients whom have underwent operative treatment for TB spine via posterior-only debridement, decompression and instrumentation and have completed a minimum of 1 year post-operative follow-up.

Inclusion criteria

1. Patients between the age of 18 – 80 years old
2. Patients diagnosed with spinal tuberculosis that were operated with single stage posterior only decompression and instrumentation from year 2003 till 2019 and has completed one year of follow-up.
3. Lesions confined to one segment or maximum up to 2 adjacent vertebral segments.

Exclusion criteria

1. The lesion with multilevel non-contiguous vertebral involvement
2. Patients with any other concomitant infection
3. Patients with vertebral body trauma or previous history of spine surgery or with congenital scoliosis were excluded.

Sample size estimation

The sample size calculation is calculated using Sample Size Calculator v2.0 (Excel format).

For objective 1, 2 and 3, sample size was calculated via single mean formula.

The parameters used were:

Alpha = 0.05

Standard deviation from established studies in literature

Estimated difference value is from clinical expert's opinion

Drop-out rate set at 0%

Confidence interval = 95%

Power of study = 80%

Objective 1: To assess the mean kyphotic correction that can be achieved via the posterior-only approach

In a literature by Gupta et.al , mean improvement in kyphosis (in degrees) is 15.6 +/- 8.0 ,

Standard deviation of 8.0 , expected variance of 2.9 and drop-out rate is 0%.

1 mean – Estimation	
Standard deviation (σ)	8.000
Precision	2.900
Significance level (α)	0.050
Drop-out	0%
Sample size	30
Sample size (with drop-out)	30

Therefore, sample size is **30**.

Objective 2 : To evaluate the extent of pain recovery achieved via posterior-only approach using VAS score

In a literature by ashish et.al , mean VAS score at final follow-up is 1.7+/- 0.864 , Standard deviation is 0.864 , expected difference is 0.300 and drop-out rate is 0%.

1 mean – Estimation	
Standard deviation (σ)	0.864
Precision	0.300
Significance level (α)	0.050
Drop-out	0%
Sample size	32
Sample size (with drop-out)	32

Therefore , sample size is 32

Objective 3 : To evaluate the resolution of TB infection via serial ESR and CRP monitoring.

For ESR :

In a literature by ashish et.al , mean ESR score at final follow-up is 14.697+/- 3.432 , Standard deviation is 3.432 , expected difference is 1.25 and drop-out rate is 0%

1 mean – Estimation	
Standard deviation (σ)	3.432
Precision	1.250
Significance level (α)	0.050
Drop-out	0%
Sample size	29
Sample size (with drop-out)	29

Sample size is 29

For CRP :

In a literature by ashish et.al , mean CRP score at final follow-up is 1.70 +/- 0.982 , Standard deviation is 0.982 , expected difference is 1.25 and drop-out rate is 0%

1 mean – Estimation	
Standard deviation (σ)	0.982
Precision	0.340
Significance level (α)	0.050
Drop-out	0%
Sample size	33
Sample size (with drop-out)	33

Sample size is 33

Objective 4 : To evaluate the neurological recovery in patients treated by posterior-only

Approach

Sample size was calculated using single proportion formula

The parameters used were : Alpha = 0.05

Proportion was taken from established studies in literature

Precision was set based on clinical expert's opinion.

Confidence interval = 95%

Power of study = 80%

In a literature by laheri et.al , proportion of neurological recovery is 91.3% , precision is set at 8.00% and Drop-out rate is 0%

1 proportion – Estimation	
Proportion (p)	91.30%
Precision	8.00%
Significance level (α)	0.050
Drop-out	0%
Sample size	48
Sample size (with drop-out)	48

Sample size is 48

Therefore, after calculating sample size separately for each objective, the final sample size determined for this study is 48.

Sampling method and subject recruitment

Sampling method is a convenient sampling which means there was no randomization of study sample. All those patients whom had underwent posterior-only debridement, decompression and instrumentation for TB spine at Hospital Universiti Sains Malaysia that falls within our inclusion criteria will be recruited as study sample. Patients would be recruited based on the information gathered from operation theatre registry and out-patient orthopaedic clinic registry.

Following recruitment, patient's clinical file will be traced to retrieve relevant clinical data.

PACZ system will be used for radiological assessment.

Research tool

Number of research tool will be used in this study :

- a) Measurements of kyphosis

PACZ radiology system will be used to assess the radiological images of spine and to measure the local kyphotic angle in the study sample (pre-operative, post-operative and at final follow-up).

- b) Assessment of pain via Visual Analogue Scale (VAS)

The Visual Analogue Scale (VAS) score will be traced from **patient's clinical notes**. If this information is not found in patient's clinical notes, patients will be called for a clinical session to recall the pain score as mentioned in the data collection section.

- c) ESR and CRP values

HUSM labarotary information system will be used to trace patient's ESR and CRP values. The same values can be traced from **patients clinical notes** as well.

- d) Assessment of Neurology

The neurological grading of patient based on ASIA impairment scale (AIS) will be traced from **patient's clinical file**.

Data collection method

We will perform a retrospective review of clinical data from patient's clinical file traced from medical record office, HUSM and radiographic data collected from readily available radiographic images from PACZ system, HUSM.

Diagnosis of active tuberculosis - clinical symptoms, physical examination, laboratory findings (complete blood count, erythrocyte sedimentation rate [ESR], C-Reactive protein [CRP], sputum for acid-fast bacilli [AFB]) and radiographic evidence (x-ray spine [AP and Lateral view], chest x-ray and MRI spine.

Histopathological examination of the biopsy sample done in all cases post-operatively to confirm the diagnosis.

For preoperative and post-operative neurological assessment, patient will be graded as per ASIA impairment scale (AIS) into one of the 5 grades ranging from A to D which is the International Standards for Neurological Classification of Spinal Cord Injury proposed by American Spinal Injury association (ASIA). This information will be traced from patient's clinical file. The neurological assessment is measured prior to operative intervention, between 6/52 to 3/12 during follow-up and at 1 year follow-up.

Patient's pain recovery is assessed based on documented Visual Analogue Scale done prior to operative intervention, between 6/52 to 3/12 post-operative period and at 1 year follow-up. The VAS score will be retrieved from patient's clinical notes. If this information is not documented in clinical notes, patient will be contacted via telephone to make special clinic

appointments to enquire patient's pain score. Those patients will be required to recall the pain intensity prior to operation, anytime between 6/52 to 3/12 post-operative periods and at 1 year follow-up.

The Visual Analogue Scale (VAS) consists of a straight line of 100 millimetres(MM) length with two endpoints defining extreme limits such as 'no pain at all' on the left end of scale (0.0 MM) and 'pain as bad as it could be' on the right end of the scale (100 MM). The patient is asked to mark his pain level on the line between the two endpoints. The distance between 'no pain at all' and the mark is measured in millimetres and converted to centimetres with 1 decimal point and interpreted as subject's pain score. Figure 2.0 in appendix. In a study conducted by Peter Salovey on a accuracy of memory for pain which was published in Journal of Pain in 1993, mentioned that self-reports of pain can generally be trusted and they appear to be recalled with reasonable accuracy and concluded that retrospective self-reports of pain collected systematically with measures of proven reliability seem relatively trustworthy.[24]

Angle of kyphosis is calculated from lateral spine x-ray (local kyphotic angle) which is measured prior to operative intervention, within 1 month after operation (immediate post-operative) and at 1 year follow-up. The local kyphotic angle is the angle in degree defined by the intersection of superior and inferior end plate of the affected vertebra. The angle of kyphosis was measured from the 2 lines drawn parallel to the superior and inferior endplates of involved vertebral levels. In a case where 2 vertebrae collapsed without trace of intervertebral disc, the 2 parallel lines were drawn from superior endplate of the superior collapsed vertebra and inferior endplate of inferior collapsed vertebrae.[29]. The measurement of kyphotic angle will be in degree with 1 decimal point (figure 4 in appendix).

ESR and CRP are taken prior to operative intervention, between 4 – 6 months post-operatively and at final follow-up between 10 – 12 months post-operative period. HUSM laboratory information system will be used to trace patient's ESR and CRP values. The same values can be traced from patient's clinical notes as well.

Meanwhile, all patients were started on standard anti-tubercular drug prior to the operative intervention.

All patients were operated under general anaesthesia and underwent posterior debridement, decompression followed by posterior instrumentation.

Follow up examination was done for a minimum up to 1 year post-operative period.

The following indexes including radiological data (kyphotic angle), hematologic parameters (ESR & CRP), pain score, and neurological function were recorded in a formatted table.

(Appendix – Table 1)

Data analysis

The data will be collected, entered and analysed using SPSS version 24 .Dependent variables would be final kyphotic angle, pain score, ESR and CRP value which will be presented in the form of mean value whereas neurological recovery is presented in the form of proportion and calculated using the student paired t-test.

As for dealing with missing data in this retrospective study, a few methods will be utilised. For VAS score, as mentioned in data collection method, patient will be contacted via telephone for a clinic appointment to recall the pain intensity.

For laboratory markers such as ESR and CRP, if values are not found in patient's clinical notes or in laboratory information system of HUSM, multiple imputation technique will be utilised to handle those missing data. With multiple imputation, multiple copies of the dataset are created, with the missing values replaced by imputed values which are sampled from their predictive distribution based on the observed data. Because we can never be sure what the missing values are, multiple imputation aims to allow for the uncertainty by creating several different plausible imputed data sets and combining results obtained from each of them. The number of imputations required should be similar to the proportion of cases with missing data. Once multiple imputation has created several complete datasets, subsequent analysis will produce output for each imputed 'complete' dataset, plus a pooled output that estimates what the results might be, had there been no missing values. The statistical analyses, (e.g. t-test or

logistic regression), are performed separately on each imputed data set, and the results are then combined into a 'pooled' or aggregated result[2].

Kyphotic angle is calculated from radiological images of spine found on PACZ radiology system. However, if those required images are missing in PACZ radiology system, the printed

spine x-ray film will be traced from the medical record office. In the event where the required radiological images are not available, unfortunately the particular patient will be excluded from this study.