Musculoskeletal
Health Network

Elective Joint Replacement Service Model of Care

November 2010

Government of Western Australia
Department of Health

Suggested Citation

Department of Health, Western Australia. Elective Joint Replacement Service Model of Care. Perth: Health Networks Branch, Department of Health, Western Australia; 2010.

Important Disclaimer:

All information and content in this Material is provided in good faith by the WA Department of Health, and is based on sources believed to be reliable and accurate at the time of development. The State of Western Australia, the WA Department of Health and their respective officers, employees and agents, do not accept legal liability or responsibility for the Material, or any consequences arising from its use.

Table of Contents

Index of Figures

Index of Tables

1. Acknowledgements

The Musculoskeletal Health Network, Elective Joint Replacement Working Party chaired by Professor Piers Yates and Dr James Williamson has developed the Elective Joint Replacement Service Model of Care.

Members of the Working Party	Title
Professor Piers Yates	Professor, University of Western Australia; Head of Department (Orthopaedics), Fremantle Hospital; Surgeon Osborne Park Hospital; Medical Director, Perth Bone and Tissue Bank
Dr James Williamson	General Physician and Rheumatologist Head of Department (General Medicine), Sir Charles Gairdner Hospital and A/Medical Director Osborne Park Hospital, North Metropolitan Area Health Service
Mr Richard Beaver	Orthopaedic Surgeon, RPH
Ms Emma Blake	Senior Physiotherapist, OPH
Dr Andrew Briggs	Senior Development Officer, WA Health Networks
Dr Vickey Brown	Clinical Nurse Manager (Orthopaedics), Fremantle Hospital and Health Service
Mr Geoff Burrell	Aged Care Policy Branch, Department of Health
Mr Anthony Dolan	Nurse Co-Director, Osborne Park Hospital
Mr Lindsay Foster	Senior Occupational Therapist
Dr Helen Gilbey	Exercise Physiologist, Hollywood Private Hospital
Ms Eleri Griffiths	Manager Surgical Services, Armadale Health Service
Ms Samantha Haebich	Physiotherapist, SCGH
Ms Diane Jones	Deputy CEO, Joondalup Health Campus
Mr Brendan Joss	Exercise Physiologist
Ms Mary Jo Kroeber AM	Director, Patient Flow, Department of Health
Mr Ed Scull	Head of Department, Medical Engineering & Physics
Ms Jayne Stanich	Project Officer, Ambulatory Care WA Country Health Service (WACHS)
Ms Karen Slonn	Project Scientific Officer, JRAC, RPH, SMAHS.
Mr Jonathon Spencer	Orthopaedic Surgeon, SCGH/OPH
Adjunct Associate Professor Robyn Timms	Head of Department Physiotherapy, Fremantle Hospital and Health Service
Dr Stephen Watts	Anaesthetist , Pre-operative Service, SCGH

Senior Development Officers at Health Networks Branch are also acknowledged for their contribution to the development of this Service Model of Care, including Belinda Whitworth and Nerida Croker. Information included in the Appendices was provided by WA Patient Blood Management Project Team (Dr Simon Towler, Mr Shannon Farmer, Prof Michael Leahy, Prof John Olynyk, Mr Axel Hofmann, Mr Michael Wren, Prof James Isbister, Dr Amanda Thomson, Dr Audrey Koay, Dr Jennifer Bruce and Dr Irwin Gross) (Appendix 1), Fremantle Hospital Health Service (Appendix 2), and Perth Bone and Tissue Bank (Appendix 3).

2. Executive Summary

Joint replacement surgery is a highly effective intervention for treating the symptoms of degenerative joint disease, particularly of the hip and knee. In Australia and internationally, the demand for total hip and knee joint replacement surgery continues to rise at about 10% per year, and this rate is expected to climb further as the prevalence of osteoarthritis increases and expectations for improved quality of life become greater. By 2016, it is anticipated that the number of hip and knee joint replacements performed will be double current rates. Therefore, there is a need for a coordinated and sustainable model of service delivery for elective joint replacement surgery in the public health system to ensure that current and future needs of Western Australians are met.

The Musculoskeletal Health Network re-established a working party in 2008 to develop a service Model of Care for elective joint replacement surgery in Western Australia. The Model describes a coordinated system of referral to orthopaedic clinics from General Practitioners (GPs) as well as the components of optimal care from point of referral to rehabilitation and long-term post-operative monitoring. The aim of the Model of Care is to address issues and offer solution to:

1. Standardise and improve the patient pathway
2. Increase efficiency, safety and quality in the services provided
3. Meet the requirements for health facilities
4. Ensure a skilled and competent workforce

The patient pathway for elective joint replacement surgery commences with primary assessment by the GP. The GP is responsible for completing a referral which ideally includes the Clinical Priority Access Criteria (CPAC) score for Orthopaedics (or equivalent priority access score) and a patient self-report surgical prioritisation score. This information, together with appropriate radiographs should be sent electronically to an orthopaedic triage centre. Once triaged, patients will be allocated to an appropriate orthopaedic specialist for clinical assessment and where deemed suitable for surgery, will be added to the orthopaedic waiting list. The orthopaedic surgeon is ultimately responsible for the patient's surgical pathway and therefore should remain in control of clinical decisions throughout this pathway.

There is evidence to suggest that a protracted waiting time is associated with a decline in quality of life and physical function, and an increase in joint-related pain. Considering the current evidence, waiting times for elective joint replacement surgery from time of referral should not exceed 180 days.

Pre-operative assessment should be performed, and education provided, preferably on a single occasion at a pre-admission clinic by a multidisciplinary team including the surgical team, nursing, anaesthetics, physiotherapy, occupational therapy and social work. The multidisciplinary assessment at pre-admission clinic should be performed after the initial assessment by the orthopaedic specialist. Information about femoral head donation options should also be provided to those patients undergoing primary hip replacement. Rehabilitation and discharge planning should also commence pre-operatively. Communication with patients and their carers should be provided in a systematic

and coordinated manner using appropriate written and verbal information. Patients should receive information at the orthopaedic clinic prior to admission, including the expected length of stay; pre-operative, procedure, recovery, pain management and rehabilitation processes.

Guidelines describing best surgical practice for joint replacement surgery should be considered in order to optimise theatre efficiency, anaesthesia, blood conservation, and for minimising the risk of thromboembolic disease and peri-prosthetic joint infection.

Post-operative care pathways provide an evidence-based framework to optimise recovery and rehabilitation outcomes. Criteria-based discharge plans may be used as a means to optimise patient care and use of resources. These processes minimise delays in discharge and variation in clinical best practice between sites.

Equally important to the referral pathway is the discharge pathway. In addition to post-operative education, rehabilitation services and post-operative review in an outpatient clinic arranged for patients who undergo elective total joint replacement surgery, the referring GP should receive a discharge summary prepared by a member of the multidisciplinary team. Ideally, discharge summaries should be made available electronically to GPs.

Health facility support services are essential to the success of joint replacement surgery. Adverse events associated with joint replacement surgery may be minimised when surgeries are performed at centres where procedure volumes are sufficiently high. A range of hospital resources are required to support elective joint replacement surgery, including appropriate medical cover, teaching and training, nursing and allied health staffing, outpatient clinics, specific operating theatre requirements, access to high levels of care and support services. Individual surgeons should operate only within their scope of clinical practice.

The introduction of new technologies to support joint replacement surgery is important for optimising patient outcomes. It is important that new technologies are assessed appropriately before their introduction into the WA public health system. Similarly, decisions about tenders for prostheses should be reached based on the best available evidence.

Key recommendations from the Elective Joint Replacement Service Model of Care include:

1. Referral Pathway

a. An electronic referral pathway should be established for patients to access outpatient orthopaedic clinics after primary assessment by a GP. The electronic pathway system should interface with existing practice software used by GPs.

b. General Practitioners should ideally use the state-wide standard prioritisation and assessment criteria (eg CPAC for Orthopaedics) and provide standardised radiographs and a surgical prioritisation score.

c. All referrals for orthopaedic assessment should be triaged by a suitably qualified triage officer using standardised protocols.

d. State-wide patient record numbers should be adopted to minimise duplication of medical records and diagnostic tests.
e. Multidisciplinary pre-admission assessment should occur prior to surgery, with sufficient time for team members to act upon any issues raised during the assessment. The assessment should include:
    i. Surgical team review
    ii. Nursing review and information provided about infection control protocols
    iii. Anaesthetic and fitness for surgery review
    iv. Physiotherapy assessment
    v. Occupational Therapy assessment including functional review
    vi. Social Work assessment
    vii. Discharge and post operative care planning
f. Utilise a screening tool at pre-admission clinic to identify modifiable physical and psychosocial factors which are known to increase length of stay and/or contribute to poorer post-operative outcomes. Pre-operative education and rehabilitation services should be offered to patients where these modifiable factors are identified.

2. Patient Information

a. Standardised or minimum criteria patient information/education should be developed or endorsed to ensure quality and consistency between centres providing elective joint replacement services. Information in languages other than English should also be made available.

3. Facilities

a. Identification of suitable centres for elective primary and revision joint replacement surgery in WA to provide the highest standards of joint replacement outcomes, teaching and research.
b. Dedicated centres should be identified for primary and complex/revision surgery and contain appropriate staff, equipment and facilities to deal with the surgery that is being performed at the site. Throughput at these sites should be adequate to maintain expertise of staff and minimise adverse events.

4. Procedure

a. Guidelines for prophylaxis to minimise thromboembolic and peri-prosthetic infection should be made available, and based on best evidence.
b. Criteria-led discharge protocols should be introduced for primary total hip and total knee joint replacement surgery to ensure consistency of care between sites, while addressing operational requirements.
c. Patients are admitted on the day of surgery.
d. Patients' planned procedures are not cancelled.
e. Pain team should be involved in the peri-operative period.
f. Patients with routine primary joint replacements are mobilised as soon as possible after surgery.

5. Joint Replacement Registry and follow up

a. All surgeons performing elective joint replacement surgery should contribute data to the National Joint Replacement Registry.

b. A single state-wide database for the collection of patient outcome data should be established to:

i. monitor the functional status of patients;
ii. ensure that patient expectations are met;
iii. provide an opportunity for further education to optimise self-management practices;
iv. allow the early detection of any post-operative problems;
v. review, quantify and report clinical and radiographic outcomes;
vi. provide opportunities for the collection of powerful longitudinal data which can be used for clinical research and audit purposes;
vii. improve the quality and efficiency of care by utilising data to inform future decision making.

c. It is recommended that a system be created at each hospital site to provide for follow-up of all patients at intervals of 3 months, 12 months, 5 years, 10 years and then 2 yearly thereafter owing to the risk of aseptic prosthesis loosening after 10 years. These timeframes largely align with the recommendations of the Arthroplasty Society of Australia and 10 year local WA Joint Replacement Assessment Clinic (JRAC). This follow-up and data collection may be performed by a physiotherapist or other health professional with delegated authority, while providing the opportunity for findings to be communicated to the surgeon and to involve the surgeon in a follow-up assessment should a clinical need arise. To ensure reliability in the outcome measures collected, particularly if data are intended for use in longitudinal studies, standardised measurement protocols should be made available to sites conducting follow-up evaluations.

d. Follow-up for patients who have undergone joint replacement surgery should occur at the operative hospital. The JRAC model provides an example of an efficient system to enable a timely review of patients with the opportunity to collect important data for clinical and research purposes.

e. Follow-up radiographs should be reviewed by orthopaedic surgeons.

f. Data should remain the property of the treating surgeons.

6. Discharge Pathway

a. At discharge, a summary should be immediately sent to the referring GP which describes the surgical procedure performed, outcomes, and post-operative care for the patient. Ideally, the discharge summary should be sent electronically.

b. Post-operative care services for the period after discharge should be arranged by hospital staff.

7. **Workforce**

   a. Surgeons performing joint replacement should only operate within their defined scope of practice and maintain their skills through peer reviewed audit and continued professional development.

   b. Research and multidisciplinary workforce development opportunities should be facilitated and encouraged by centres where elective joint replacement surgery is undertaken.

   c. Opportunities should be made available for surgical trainees to work across an area health service in both tertiary and non-tertiary hospital sites.

8. **Prosthetics**

   a. A revised and acceptable tender for prostheses should be developed based on best evidence, and enforced in public hospitals. Exceptions for the use of implants outside the tender process should be made on an individual patient basis or part of a clinical trial, rather than purely on surgeon preference.

   b. Any new technologies for joint replacement surgery should be assessed through an appropriate body such as the Western Australian Policy Advisory Committee on Clinical Practice and Technology (WAPACT) or the joint replacement tender committee, before their introduction into the WA public health system.

9. **Radiology**

   a. A standardised state-wide system of electronic linkage between the public and private radiology providers should be established to enable timely access to diagnostics, reduce duplication of radiographs, minimise cost, avoid unnecessary exposure to ionising radiation and facilitate audit and research.

Implementation of these recommendations across area health services must be considered in the context of operational factors at a local level and Activity Based Funding priorities for WA Health.

3. Methodology

3.1 Service Model of Care

The Musculoskeletal Health Network identified a service model for elective joint replacement as a priority, given the increasing number of surgical procedures being performed and the evidence pointing to deterioration in health-related quality of life experienced by individuals on protracted waiting lists for surgery. The Elective Joint Replacement Working Party was convened in 2008 to develop a Service Model of Care for elective joint replacement surgery in Western Australia. To assist with identifying best practice over the continuum of health, relevant literature and existing service models were reviewed. The Elective Joint Replacement Service Model of Care has been developed to encourage best practice and optimise patient outcomes, in a cost effective and efficient manner with a focus on quality and safety that is sustainable within the public health system whilst maintaining a patient-centred focus.

4. Introduction and Background

4.1 Scope of Elective Joint Replacement Service Model of Care

Joint replacement surgery refers to the surgical replacement of the articular surfaces of a joint with a suitable prosthesis. This service Model of Care is limited to the provision of elective total hip and knee joint replacement surgery. It includes primary replacement and revision surgery.

4.2 Contribution to the Burden of Disease

Osteoarthritis (OA) is the most common musculoskeletal disorder experienced by Australians, affecting about 15% of the population [1], and contributing to significant pain and disability. Moreover, OA is the most common condition leading to joint replacement surgery at the hip and knee. Approximately 89% of total hip replacements and 97% of total knee replacements performed in Australia are due to OA [2]. Rates of joint replacement of surgery continue to rise at about 10% per year, and the rate of increase is expected to escalate further [2-3], due to a rising prevalence of OA, greater expectations for enhanced quality of life, and improved surgical and anaesthetic techniques [2]. Projections from the National Joint Registry suggest that the demand for hip and knee joint replacements will increase by 100% every decade [2]. For example, an additional 32,717 hip procedures and 39,283 knee procedures were reported to the National Joint Registry up to 31 December 2008, representing a 4.4% and 6.3% increase, respectively, from the previous annual report [2]. Therefore, there is a need for a coordinated and sustainable model of service delivery to ensure that current and future needs of Western Australians are met with respect to joint replacement surgery.

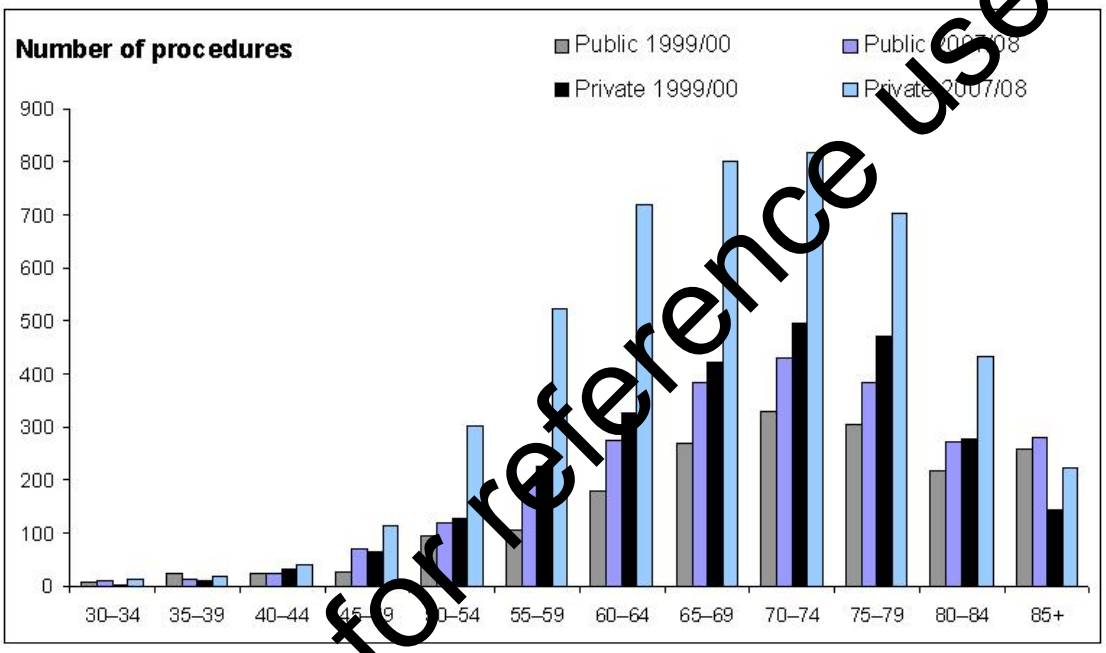
Primary joint replacement surgery significantly improves patient quality of life, physical function outcomes [3-6], and represents a cost effective means of treatment for OA [7]. However, prosthesis failure requiring revision surgery imposes a significant burden of mortality, morbidity, cost and impaired quality of life when compared with primary procedures [8-9]. Data from the Australian Orthopaedic Association Joint Replacement Registry suggest the eight year cumulative incidence for revision of total primary hip and knee joint replacement surgeries are 4% and 5%, respectively [2]. Although there are many factors which contribute to the need for revision of total joint replacement, establishment of best service delivery through implementation of a model of care as well as utilisation of the National Joint Replacement Registry data to identify optimal devices and may minimise the need for revision surgery.

Joint replacement surgery is predominantly performed on an older population with a significant number of co-morbid medical conditions including cardiac, respiratory, renal, diabetic, and obesity-related conditions. The presence of co-morbidities represents an increased risk for needing revision surgery at a later stage [10]. Joint replacement surgery is a major interventional risk factor in the causation of thromboembolic disease (DVT and pulmonary embolus) and carries a significant risk for heart attack, heart rhythm abnormalities, acute renal dysfunction or kidney failure, blood loss, blood transfusion, pneumonia, pulmonary fat embolus syndrome, acute delirium, stroke and other medical problems.

4.3 Demand for Elective Joint Replacement Surgery Within Western Australia

The number of hip and knee elective joint replacements continues to increase in Australia and internationally [2, 11]. Nationally, the rate of increase for joint replacement surgery is expected to continue such that the number of hip and knee replacements will double by 2016. Figure 1 illustrates the significant increase in the number of elective joint replacement procedures performed between 1999 to 2008 in WA, particularly in the over 50yr age group, as well as a shift from the public to private sector over this eight year period.

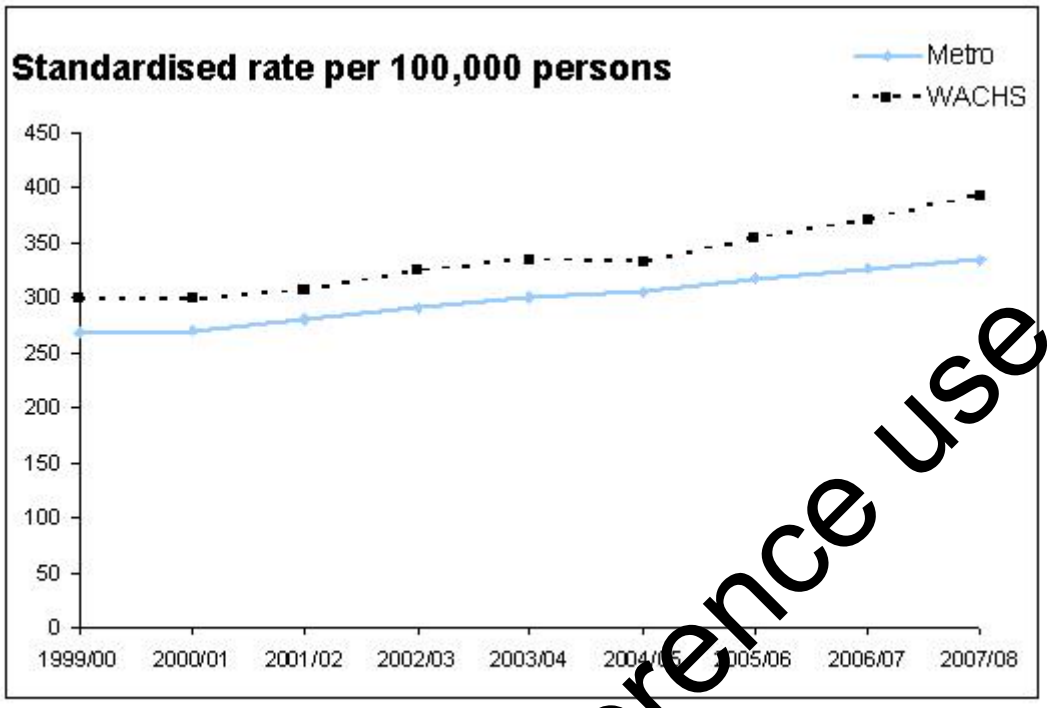
Figure 1 Number of Public and Private Hospital Separations For Joint Replacement Surgery in 1999/00 and 2007/08 by Age in WA



Source: Epidemiology Branch, Department of Health (WA).

Similarly, Figures 2 illustrates the upward trend in elective joint replacement surgeries across metropolitan and regional WA.

Figure 2 Age-Standardised Rate of Elective Joint Replacement Surgeries Performed Between 1999/00 to 2007/08 Across Metropolitan (Metro) and Regional WA (WACHS).

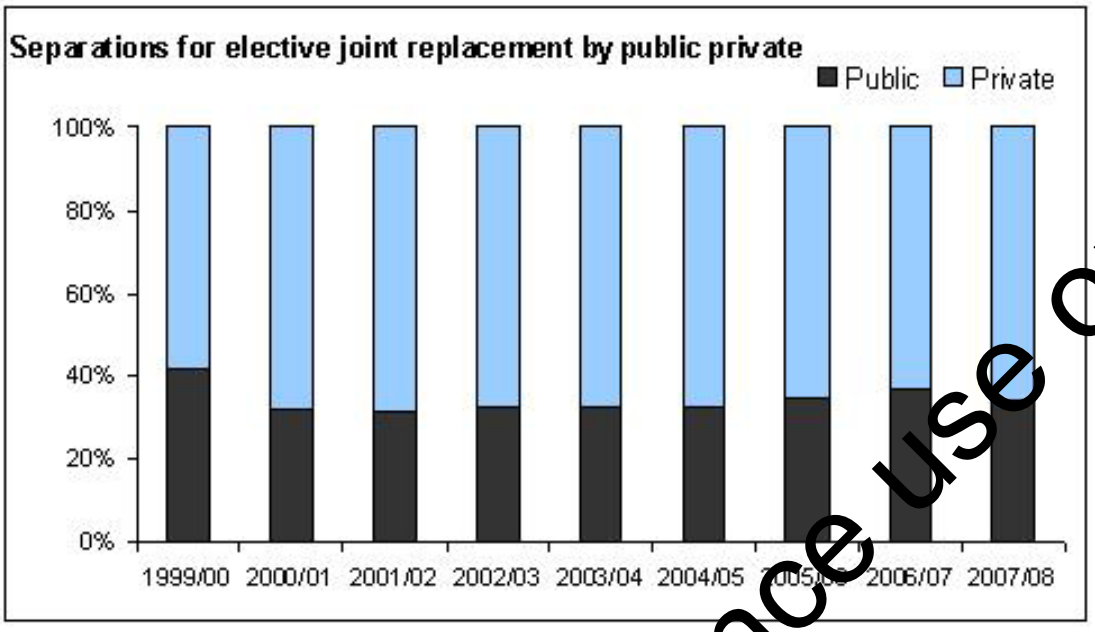


Source: Epidemiology Branch, Department of Health (WA).

The WA hospitalisation data indicate that between 1999/2000 and 2007/08 a decrease in the proportion of joint replacements in the public sector from 41% to 34% was observed, while an increase from 59% to 66% was observed in the private sector (Figures 1 and 3). The trend for a greater proportion of private elective joint replacement surgery was observed across the state, other than the Kimberley region where a slightly higher proportion was performed in the public system (Figure 4).

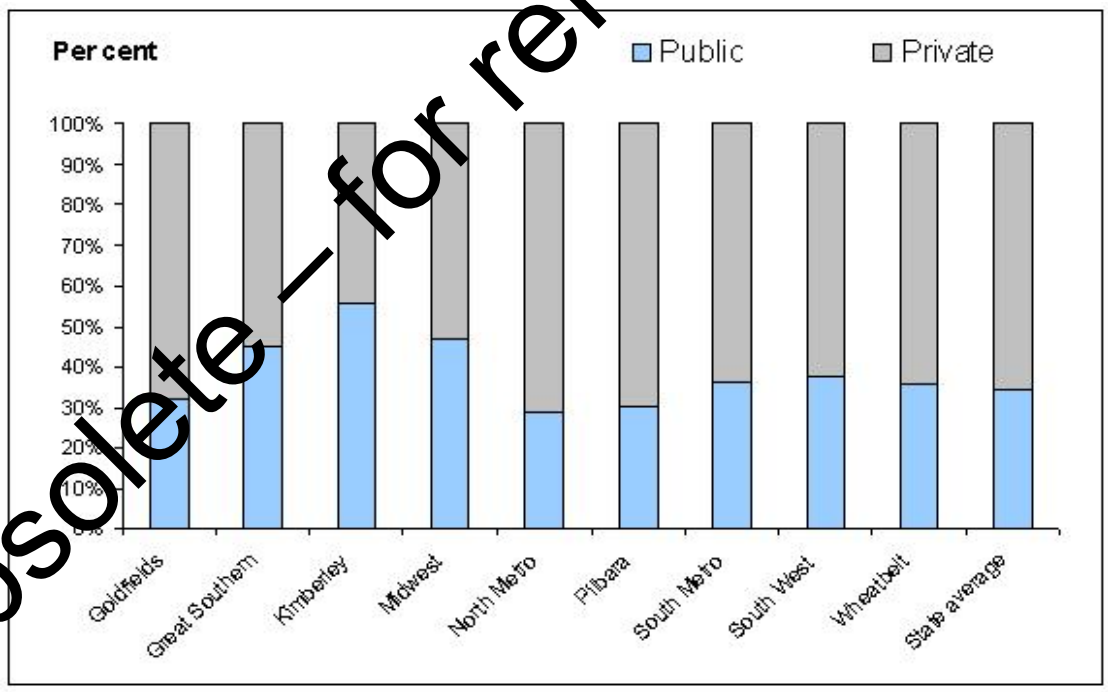
In WA the number of hip and knee replacements has continued to increase. Projections based on the current numbers of hip and knee replacements indicate that between 2008 and 2016 the total number of cases will increase by 53%. If this public - private trend continues to 2016, the public system will require capacity for an additional 1241 joint replacement procedures and the private sector 2416 cases.

Figure 3 Separations for Elective Joint Replacement by Public or Private Hospital 1999/00 to 2007/08



Source: Epidemiology Branch, Department of Health (WA).

Figure 4 Place of Residence By Public or Private Hospital For Elective Joint Replacement in 2007/08



Source: Epidemiology Branch, Department of Health (WA).

4.4 Waitlist Time for Elective Joint Replacement Surgery

Long waiting lists for hip and knee elective joint replacement surgery are not uncommon and may be influenced by a number of factors including increased demand, workforce shortages, and inefficient prioritisation systems. The length of the waiting list is irrelevant to the patient; rather it is the total waiting time which is most important. The duration of time an individual spends on the waitlist for primary or revision elective joint replacement surgery is an important factor influencing pre-operative pain and function, and these factors are known to influence the post-operative outcome [12]. Quality of life and psychosocial function deteriorate significantly in patients during the waiting period [13], suggesting that monitoring patient status during this period may be indicated. Although there are several clinical studies suggesting functional declines in patients who remain on surgical waitlists, the quality of these studies vary considerably, making evidence-based decisions about acceptable waitlist times difficult. A recent study of patient expectations concerning waitlist times for hip and knee replacement surgery reported that 13 weeks was the median maximal acceptable wait time perceived by patients, while the median unacceptable wait time was 22 weeks [14]. A recent systematic review concerning the impact of wait time for total hip and knee joint replacement on pain and function synthesised data from 15 studies where the waiting time period was defined as the time between the date of the decision to treat surgically and the actual date of surgery [15]. Short wait times were defined as <180 days and long periods as ≥180 days. There was strong evidence that pain (hip and knee) and self-reported function (hip) do not deteriorate in patients waiting for joint replacement surgery in the short term (<180 days). There was conflicting evidence regarding functional decline in patients waiting for knee joint replacement in the short term. When relying on moderate quality studies, there was strong evidence that patients experience increased hip pain and limited evidence for increased knee pain when waiting for ≥180 days. Conflicting evidence was reported for deterioration in functional status in patients waiting ≥180 days for primary hip or knee replacement surgery. A similar observation has been reported for patients on a waitlist for revision hip surgery. Davis et al [16] reported significant increases in pain and disability when waiting time exceeded six months, but not earlier, although these conclusions were based on a small sample size.

Considering these data, it would be preferable to limit waiting time duration to <180 days for patients scheduled for elective total joint replacement in WA. Currently, waiting list studies report only outcomes for the time period representing the point of enrolment on a surgical waitlist to day of surgery. There are no data describing patient-centred outcomes for the time period from presentation to the GP to day of surgery. Clearly, this time period may be far more protracted than the time from waitlist enrolment to surgery. Hence we would recommend that the total waiting time from GP referral to surgery for primary joint replacement be <180 days until further evidence becomes available.

Table 1 provides the quarterly median wait time (days) for total joint replacement in WA from 2006-2008, representing the period from enrolment on a surgical waitlist to the day of surgery. Data represent the median waiting time in both metropolitan and regional centres. Table 2 provides wait time for total hip and knee joint replacements in Australian states and territories using data from the

National Elective Surgery Waiting Times Data Collection (NESWTDC) project reflecting patients admitted from public acute hospital elective surgery waiting lists. The 50th percentile represents the number of days within which 50% of patients were admitted; half the waiting times will have been shorter, and half the waiting times longer, than the median. The 90th percentile data represent the number of days within which 90% of patients were admitted. It must be taken into consideration that this time does not include the waiting time to get onto the surgical waiting list, which is currently unknown and highly variable between centres.

Table 1 Median Wait Time (Days) for Admission by Quarter (Q) for Hip, Knee And Shoulder Replacements (Combined) by Area Health Service, 2006-2008

	2006 Q1	2006 Q2	2006 Q3	2006 Q4	2007 Q1	2007 Q2	2007 Q3	2007 Q4	2008 Q1	2008 Q2	2008 Q3	2008 Q4
Metro North	89	72	85	74	86	97	64	70	83	77	58	61
Metro South	167	207	171	124	124	155	102	124	115	121	92	80
Goldfields	66	42	37	39	103	34	75	0	0	0	0	0
Great Southern	42	54	199	247	272	216	153	188	61	68	104	66
Midwest	341	481	526	494	405	317	154	77	123	79	17	22
South West	44	52	74	73	197	145	146	111	106	101	80	140
TOTAL	**110**	**120**	**127**	**99**	**120**	**15**	**95**	**104**	**105**	**106**	**77**	**75**

Source: Epidemiology Branch, Department of Health (WA).

Table 2 Waiting Time (Days) for Patients Admitted From Waiting Lists for Elective Surgery by State and Territory, 2007-08

	NSW	Vic	Qld	WA	SA	Tas	ACT	NT	Total
Total hip replacement									
Admissions	2,876	1,621	1,380	795	603	[illegible]	188	23	7,688
Days waited at 50th percentile	134	121	62	84	114	[illegible]	185	129	107
Days waited at 90th percentile	357	405	230	246	484	679	478	928	359
% waited more than 365 days	6.3	12.7	3.3	3.1	[illegible]	39.6	21.3	21.7	8.9
Total knee replacement									
Admissions	4,791	1,836	2,039	[illegible]	724	219	214	24	10,947
Days waited at 50th percentile	235	166	77	[illegible]	207	381	226	292	160
Days waited at 90th percentile	367	505	294	307	656	762	496	618	386
% waited more than 365 days	10.5	18.7	[illegible]	5.7	34.9	53.9	25.2	37.5	13.6

Source: Australian Hospital Statistics 2007-2008, Australian Institute of Health and Welfare (AIHW) (2009), Canberra.

5. Elective Joint Replacement Model of Care

5.1 Introduction and Rationale

The WA Health system does not have a state-wide pathway for referral, assessment and prioritisation of public patients requiring elective joint replacement surgery. While the standard of care may be high, a number of areas for improvement have been identified that would result in better patient pathways and outcomes, and a more responsive health system.

The NHS Institute for Innovation and Improvement report "Delivering Quality and Value; Focus on: Primary Hip and Knee Replacement" [17] identified that the clinical pathway in the high performing NHS Trusts for hip and knee replacements were underpinned by six overarching characteristics; including:

1. Patients' expectations are consistently managed.
2. Patients are admitted on the day of surgery.
3. Patients' planned procedures are not cancelled.
4. Patients are mobilised as soon as possible after surgery.
5. Patients are discharged using a criteria-based system.
6. Decision to change services to support these principles and optimise patient care and workforce productivity.

In WA current practice is site specific and varies from a length of stay of 2 days post primary hip replacement and 3 days for primary knee replacement to more than 9 and 11 days, respectively.

The Elective Joint Replacement Working Party has identified a number of areas where improvements could be achieved in the delivery of elective joint replacement services across WA Health; including:

- Need to demonstrate the quality and consistency of outcomes for patients having joint replacement surgery.
- Streamline referral process, particularly with the introduction of electronic referral and discharge information exchange.
- Standardise criteria for referral and assessment.
- Provide consistent high quality patient information, including information in languages other than English.
- Improve efficiency and patient experience of assessment.
- Reduce length of stay.
- Improve access to rehabilitation and follow-up services through care closer to home. Policies and procedures should be developed to enable coordination of this initiative across area health services.
- Have a single database for the collection of patient outcome data.
- Develop and maintain centres of excellence for joint replacement surgery and training in joint replacement surgery.
- Containment of cost.

The service improvements can be categorised in four areas and this document will address the issues and offer solutions to:

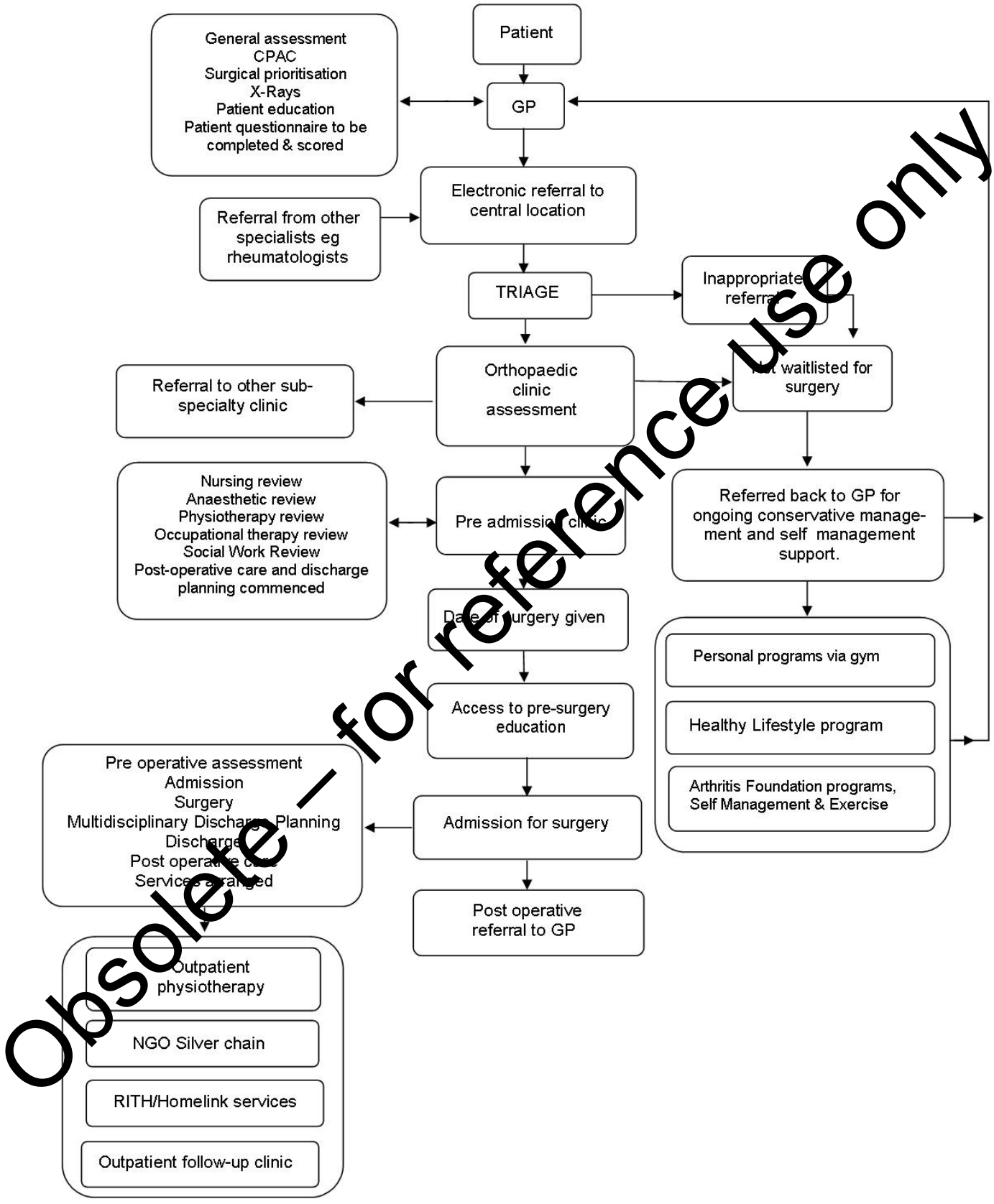
1. Standardise and improve the patient pathway.

2. Increase efficiency, safety and quality in the service provided.
3. Meet the requirements for health facilities.
4. Ensure a skilled and competent workforce.

This section describes the desired patient pathway (Figure 5) and sets out the minimum service requirements and standards as appropriate, to achieve an effective and efficient service delivery model for WA Health. The key sections are:

1. GP referral (referral and assessment)
2. Triage (referral and assessment)
3. Orthopaedic outpatient clinic (Pre-operative)
4. Processes prior to admission (Pre-operative)
5. Admission (Peri-operative)
6. Procedure (Peri-operative)
7. Recovery (Peri-operative)
8. Rehabilitation (Post-operative)
9. Discharge and Follow up (Post Operative)
10. Prostheses and technology
11. Health Care Facilities
12. Workforce

Figure 5. Patient Pathway



6. Patient information

Patient information and adequate health literacy underpins the success of each component of the patient pathway from GP referral to discharge. Patient information should be delivered in a consistent manner to provide them with a clear picture of the "patient pathway", from assessment through to follow-up care to ensure their expectations are managed. All stages along the pathway provide an opportunity to educate and inform patients of the processes and the respective role of the patient and health professionals in the management of their care before, during and after the surgery. Patient education and information can be delivered in a number of ways including face-to-face sessions, written material, and access to online information. Education of carers and family is important as they often play a key role in patient care pre and post surgery.

6.1 Patient Education

Consistent communication with the patient needs to be provided in a coordinated and systematic way. This can be achieved through the following:

- Standardised information material, such as brochures.
- Hip and knee education provided by a multidisciplinary team at pre-admission clinic, including visual information shown in clinic waiting rooms or that can be taken home.
- Clear pathway and care plan communicated at initial consultation with the multidisciplinary team which includes information about the assessment, processes prior to admission including expected length of stay, pre-operative processes, the surgical procedure, the recovery period, pain management strategies and the rehabilitation pathway.
- Dental Treatment Guidelines [18], including the position statement of the Arthroplasty Society of Australia.

Information should be made available in languages other than English.

7. GP Referral and Prioritisation Process

7.1 GP Referral (Referral and Assessment)

The GP is responsible for the primary assessment and care of patients requiring elective joint replacement.

In order to introduce a greater level of consistency and equity to the system, as well as ensuring that the *right care* is provided at the *right time* it is recommended that the GP referral to an orthopaedic specialist include a surgical prioritisation score derived from a standard patient self-report prioritisation tool such as the Oxford Hip and Oxford Knee questionnaires or the Multi-attribute Arthritis Prioritisation Tool (MAPT). Prioritisation tools may be used to inform a referral triage officer with respect to appointment scheduling and may also be used to monitor any deterioration in functional status while a patient remains on the waitlist.

The Oxford questionnaires are completed by the patient. A score can be calculated by the GP or the orthopaedic triage officer. The Oxford questionnaires consist of 12 items, each scored on a 5 point Likert scale, creating a total score between 12-60 (minimal to significant disability). Questions relate to severity of pain, self care, and functional mobility in the last 4 weeks. The questionnaires have been shown to possess good psychometric properties [19-20] and are used internationally, thereby providing opportunities for comparison and data pooling. The MAPT, developed in Victoria, is an 11 item instrument with response categories reflecting an increasing magnitude of disease burden, based on a Guttman scale. Questions contained in the MAPT are unbiased towards the hip or knee and the tool has a broader focus than the Oxford tools. Reliability and concurrent validity for the MAPT have been established [21].

Ideally, GP referrals should be sent via electronic secure messaging to a triage centre. The triage centre catchment area is yet to be defined and may vary between regional and metropolitan centres, but is likely to be based on the patient's residential postcode. Ultimately, all referrals to specialist clinics in WA Health will become electronic and utilise inbuilt decision trees to provide a state-wide clinical priority access criteria (CPAC) rating (or equivalent) and prompt the referrer to include and attach required information.

Consideration should also be given to obese patients who are referred for elective joint replacement surgery. Patients who are obese present greater surgical and post-operative care challenges. An example of referral guidelines for obese patients is provided in Appendix 2.

Referral Process: GP to Orthopaedic Specialist

1. Complete WA Health referral (ultimately, an electronic template)
2. Ideal components for GP referral:
   - General health and symptoms assessment.
   - Clinical Priority Assessment Criteria (CPAC) score (or equivalent priority access score)
   - Patient self-report surgical prioritisation score, e.g. Oxford or MAPT score.
   - Radiographs:
     - Total Hip Replacement: AP pelvis image centred on the pubic symphysis and a lateral image of the affected hip.
     - Total Knee Replacement: weight bearing AP image, lateral image, and skyline image at 30 degrees flexion.

Patients should not be unnecessarily exposed to ionising radiation and all efforts should be made to reduce duplication of radiographs. Electronic exchange of radiographs requires linkage of the various radiological service providers around the State. Electronic networking of image databases also has enormous advantages in preventing the loss of images, and allowing easy long-term radiological surveillance and research.

3. Submit referral to triage centre

7.2 Triage (Referral and Assessment)

All referrals for orthopaedic assessment will be triaged by a triage officer (e.g. nurse or physiotherapist) using standardised protocols and the prioritisation tool to identify and prioritise all patients suitable for orthopaedic specialist review for elective joint replacement. The role of the triage centre is to allocate patients to orthopaedic outpatient clinics appropriate to the complexity of the case, availability of the specialist, and availability of facilities. There will be a process for the triage officer to consult with orthopaedic surgeons to make triage decisions for some cases. For example, some cases will have a greater urgency such as revisions with risk of fracture, infection, or possible tumours. Central triage can avoid disparity between outpatient waiting times by appropriately matching demand to resource availability as well as promoting consistency across the Department of Health.

In some centres, particularly regional centres, referrals are made direct to visiting surgeons in their private rooms. While this arrangement circumvents the need for a central triage unit, it may delay the patient reaching the facility and/or expertise most appropriate for their condition.

7.3 Outpatient Orthopaedic Clinic Review (Pre-operative)

Triaged patients will be allocated to an orthopaedic clinic for review by an orthopaedic specialist and members of the multidisciplinary team. These clinicians will conduct a clinical assessment to determine need and priority for joint replacement surgery. The orthopaedic surgeon is ultimately responsible for the patient's surgical pathway and therefore should remain in control of clinical decisions throughout this pathway.

Where patients are deemed suitable for surgery, the following steps will be followed:

1. The patient will be asked to complete a 'consent to surgery' form after they have been provided with all relevant information about their surgery from the orthopaedic surgeon in accordance with the Royal Australasian College of Surgeons policy surrounding informed consent. The consent process should also be consistent with the Department of Health (WA) policy concerning consent to treatment within the Western Australian health system [22].
2. The patient will be added to the waitlist and provided with an anticipated date of surgery.
3. The patient will, in the majority of cases, be operated on and cared for by the team who conducted the clinical assessment. However, in some cases patients may be given the option to be operated on by a different surgeon, or at a different site. This option might be offered if a significant disparity between waiting times and availability of service develops which will impact on the patient's function and/or quality of life.
4. Where patients are deemed unsuitable for surgery they will be referred back to their GP and/or community-based primary care services for self management, weight loss assistance and exercise programs.

7.4 Processes Prior to Admission

7.4.1 Pre-operative Assessment & Education

A pre-operative assessment will be performed at the pre-admission clinic by the multidisciplinary team, including the surgical team, nursing, anaesthetics, physiotherapy, occupational therapy and social work. Patients will ideally be seen in this clinic on the same day and in the same location as the outpatient orthopaedic clinic (refer to 7.3). The focus of consultations is patient education, pre-admission and pre-operative preparation, compliance and discharge planning. These assessments will minimise the chance of unexpected cancellation on the day of admission by identifying factors that may jeopardise the surgical procedure or post-operative recovery. Timing of this clinic appointment needs to incorporate sufficient time to manage any issues that arise from the assessment. Assessments include:

1. The **nurse-led pre–operative assessment** focuses on optimisation of the patient for surgery ensuring standard protocols for infection control (MRSA, pre-operative wash) are adhered to, blood tests are ordered and anaesthetic check is undertaken.
2. An **anaesthetist-led risk assessment** including fitness for surgery.
3. The **physiotherapy assessment** includes a physical review (e.g. range of motion, strength, muscle tone, functional mobility) and subjective assessment (joint problem history and exercise history). An updated pre-operative clinical scoring, using the Oxford or MAPT prioritisation tools, may also be undertaken at this time.
4. An **occupational therapy** assessment includes a more detailed home environment review and assesses the need for assistive devices and intervention for activities of daily living, including, for example self care, transport and cognition.

5. A **social work** assessment includes a review of social support, work, home situation and financial status.

Rehabilitation and discharge planning at the pre-operative assessment is the role of the multidisciplinary team. An important component of discharge planning is the preparation of a discharge summary sent to the referring GP.

7.4.2 Education and Pre-Operative Therapy

A recent Cochrane Review found no evidence to support pre-operative education for hip and knee joint replacement surgery to improve post-operative outcomes. However, the review identified that education was beneficial in reducing pre-operative anxiety and may improve post-operative outcomes when tailored to patient needs [23], and probably improves patient satisfaction. Moreover, education may encourage uptake of exercise programmes and appropriate self management practices to optimise mental and physical health prior to surgery during the waitlist period. This may be particularly important for patients where modifiable physical and psychosocial factors have been identified at pre-admission clinic.

It is acknowledged that there is some evidence to support pre-operative physiotherapy, particularly for hip replacement surgery [24,25] however the cost benefit of this service for a large cohort of patients is neither cost effective nor sustainable in the public system.

All patients undergoing a total hip replacement should be provided with information and, as appropriate, a donor information Pack for **femoral bone tissue** at the time they attend the pre-admission clinic**.** The Perth Bone and Tissue Bank (PBTB) protocols (Appendix 3) should then be followed which includes interviews with the potential donor and management of the collection of the femoral head and specimens at the time of surgery.

7.4.3 Pre-Operative Management

Following pre-admission clinic, any diagnostic tests requested and response to therapies initiated should be reviewed and signed off by the care team, and in particular the surgical team, prior to admission. Where necessary, further investigations should be initiated to confirm fitness for surgery prior to the day of surgery, for example anaemia and/or iron deficiency screening and the results of these investigations communicated to the surgical team.

Patients who are identified as having pre-operative anaemia (Hb < 120 g/L in females and Hb < 130 g/L in males) or iron deficiency (non anaemic patients with ferritin < 100 μg/L) should be treated as appropriate prior to surgery, either by their GP, the multidisciplinary orthopaedics team, or a suitable nominated coordinator such as a Patient Blood Management Clinical Nurse Consultant (see Appendix 1).

For complex admission cases (for example patients with cerebral palsy or renal dialysis) a complex admission nurse or coordinator should be appointed to manage the admission and post-operative care processes.

The surgical team should be involved in the pre-operative management process at all stages. It is only through adequate communication between members of the team that the patient pathway will be optimised.

Guidelines, Procedures and Protocols

1. Multidisciplinary Pre-Admission Clinic includes:
   - Surgical team review
   - Nursing review and information provided about infection control protocols
   - Anaesthetic and fitness for surgery review
   - Screen for anaemia or iron deficiency (if applicable)
   - Physiotherapy assessment
   - Occupational Therapy asssessment
   - Social Work assessment
   - Discharge and post operative care planning
2. Consent to surgery consistent with Department of Health (WA) policy
3. Booking date
4. Perth Bone & Tissue Bank – Femoral Head Donation Information Pack provided
5. DVT risk assessment using hospital-specific DVT risk assessment tool. Guidelines have been produced for the prevention of thromboembolism in Australia and New Zealand
6. Patient provided with written information about their surgery and post-operative care to take home, including a fact sheet on Patient Blood Management Guidelines
7. Complex admission nurse or coordinator involved where appropriate

8. Admission

Implementation of the the pre-admission processes and guidelines described in the previous section will ensure, that for the majority of patients, the pre-booked date surgery will coincide with the actual date of admission. Patients should be admitted on day of surgery, rather than the night before, consistent with NHS Criteria [17].

9. Procedure

9.1 Surgery

Best-practice surgical procedures should be followed to ensure the optimal surgical outcomes for patients. Guides to good surgical practice have been developed by the British Orthopaedic Association for primary total hip replacement and primary total knee replacement.

Operating theatre efficiency is also recognized as an important factor in safety, quality of care, and efficient use of resources. A guide to theatre efficiency has been published by the Association of Anaesthetists of Great Britain and Ireland, and provides a framework to optimise theatre efficiency.

The anaesthetic intervention forms a critical component of the surgical procedure. The Australian and New Zealand College of Anaesthetists has produced a series of professional, technical and education policies to maximise safety, quality of care, and efficient use of resources associated with anaesthetic procedures. Surgeons and anaesthetists should reach a combined decision regarding the choice of anaesthesia and post-operative analgesia.

Both national and state policies and procedures have been established to ensure that the *correct* surgical procedure is performed on the *correct* patient on the *correct* site.

Data required for the National Joint Replacement Registry should be completed at the time of surgery.

9.2 Thromboembolic Prophylaxis

Considering the risk of thromboembolic disease associated with joint replacement surgery, individual hospitals should have thromboprophylaxis guidelines in place consistent with:

- The Arthroplasty Society of Australia guidelines
- National guidelines
- International guidelines

Although thromboembolic prophylaxis maybe under-used in Australian hospitals[3], the introduction of appropriate guidelines can improve the prescription of prophylactics [27]. Guidelines will require regular review and updating to ensure appropriate prophylaxis and reflect advances in the field. Ultimately, the decision and responsibility to implement thromboprophylaxis and ensure sufficient duration of treatment remains with the surgeon, particularly with respect to weighing the efficacy of pharmacologic intervention against the risk of other complications.

9.3 Infection

Joint replacement surgery also carries a risk of peri-prosthetic infection. To mediate this risk it is important that a broad spectrum antibiotic agent is administered before incision and at least 20 minutes before the application of a tourniquet, and during the first 12 hours post-operatively.

Guidelines concerning antibiotic prophylaxis to prevent infection should be made available at each centre based on available evidence and local microbiological advice. The American Academy of Orthopaedic Surgeons has released guidelines regarding intravenous antibiotic prophylaxis in primary total joint replacement as an example.

9.4 Safety and Quality

Surgeons performing elective joint replacement surgery should participate in departmental audits in addition to the Western Australian Audit of Surgical Mortality (WAASM). WAASM is an external, independent and confidential peer review surgical audit adapted from the Scottish Audit of Surgical Mortality and is designed to provide feedback by surgeons to surgeons to inform, educate, facilitate change and improve practice of all clinicians.

Guidelines and Protocols

1. Consent to surgery and patient identification and confirmation of operation site.
2. Type of anaesthetics – spinal, epidural, block – as decided by the pain team (surgical and anaesthetic combined decision).
3. Anaesthetist-led pain management team
4. Make DVT prophylaxis policy available. The British Hip Society guidelines (2009) for antithrombotic therapy are:
   a. Ensure that appropriate patient risk assessment is performed, such as the NICS Venous Thromboembolism Risk Assessment Form.
   b. Record any decision to treat or not to treat in the patient notes.
   c. Have a unit and uniform written policy.

   Best practice guidelines for DVT prophylaxis in Australia and New Zealand and internationally are also available. NHMRC guidelines for DVT and pulmonary embolism in patients admitted to Australian hospitals have also been compiled.
5. Make antibiotic prophylaxis policy available, such as the American Academy of Orthopedic Surgeons Policy.
6. Refer to blood conservation guidelines, for example those being developed through the National Blood Authority and the Western Australian Patient Blood Management Project (Appendix 1).

10. Recovery (Post-operative)

The recovery period aims to achieve the best outcome for the patient based on best practice. The accelerated rehabilitation programme includes pain and wound management, mobilising within 24 hours and ongoing rehabilitation initiatives in preparation for discharge. In order for accelerated rehabilitation programmes to run effectively, a workforce of adequate volume is required.

10.1 Criteria led Discharge

The quality standards of care at pre-admission clinic and peri-operative planning influence the length of stay and patient outcomes. Care pathways, leading to a criteria-based discharge plan are used as a means to reduce cost and optimise patient care through promotion of best practice and optimal use of resources. A recent meta-analysis examined the efficacy of joint replacement clinical pathways compared with standard medical care in 22 studies [28]. The authors reported that individuals on a clinical pathway suffered significantly fewer post-operative complications, had a significantly shorter length of stay and accounted for significantly lower costs during the hospital stay, compared to individuals on non-pathway based care.

Criteria-led discharge provides clear protocols for nursing staff, physiotherapists and occupational therapists to help define when a patient is ready for discharge. This process prevents delays in discharge and variation in clinical best practice [17]. However, the surgeon in charge of the patient is ultimately responsible for the patient's care, and they should remain in control of the clinical decisions.

The length of stay for straight forward primary hip replacements can be as low as two post operative days and three days for knee replacements. However, reductions in average lengths of stay and re-admission rates to hospital are only achievable if appropriate levels of community, home and other non-inpatient services are available. This is also particularly relevant to safe postoperative wound management, which can only be achieved with adequately skilled and resourced care in the community working from wound management guidelines formulated in conjunction with the surgical team.

The provision of ambulatory and community care in the context of rehabilitation and restorative care is required.

Patients must also be discharged with appropriate post-operative education, particularly with respect to post-operative medication (including effective usage of pain medication) and functional mobility. At the time of discharge, a summary of the surgery performed, outcomes, and post-operative care recommendations and precautions should immediately be sent to the referring GP from the multidisciplinary team. The discharge summary may ultimately be communicated through an electronic process, but until such time as processes and systems are developed to support this initiative, a fax transmission should be used. It is essential that communication between the hospital-based care team and GP is maintained to minimise chances for post-operative complications.

Guidelines and Protocols

1. Criteria led discharge protocol.
2. Discharge to community care (referral pathways).
3. Pain management.
4. Wound management.
5. Post operative education (verbal and written) including dental guidelines [18] and position statement of the Arthroplasty Society of Australia, guidelines for antibiotic prophylactics to prevent infection of artificial joints, and guidelines for driving.

11. Rehabilitation

Rehabilitation planning for patients undergoing total joint replacement surgery should be coordinated by the multidisciplinary care team and initiated during pre-admission clinic.

Post operatively, patients should be mobilised as soon as possible after surgery, in line with an accelerated rehabilitation programme. A recent Cochrane review reported that early commencement of multidisciplinary inpatient rehabilitation and adherence to a clinical pathway after total hip or knee joint replacement surgery was effective in more rapid attainment of functional milestones, a shorter hospital stay, fewer post-operative complications and incurred cost savings [29]. Accelerated rehabilitation programmes during the inpatient setting therefore have the potential to offer benefits to the patient and health system.

Providing rehabilitation in a home setting, rather than an inpatient setting, may offer advantages to patients and their carers, and minimise the cost of acute hospital care. A recent randomised controlled trial comparing inpatient rehabilitation with home-based rehabilitation reported no difference in post operative complications, function, quality of life or satisfaction between home-based and inpatient-based groups, and demonstrated a significant cost saving [30], supporting the concept of home-based rehabilitation. However, the effectiveness and safety of such models is contingent on:

- Appropriate clinical referral criteria to judge the suitability and safety of home-based rehabilitation
- Availability of a carer
- Adequate post acute support services
- Effective and early discharge planning processes
- Adequate provision of assistive devices and equipment
- Appropriately qualified and experienced therapists

The efficacy of post-operative rehabilitation, such as exercise therapy and hydrotherapy after discharge from hospital is uncertain, yet these interventions are used widely in Australia. Although many trials have been conducted to evaluate the efficacy of exercise and physiotherapy interventions after total hip or knee joint replacement surgery definitive conclusions are difficult to reach owing to the diversity in quality of the published studies and the relatively small effect size of rehabilitation interventions relative to the effect size of the surgery itself. For example, recent systematic reviews have been unable to reach conclusions regarding the efficacy of post operative rehabilitation therapies after hip and knee joint replacement surgery [31-32], while other systematic reviews suggest that physiotherapy-based exercise after discharge following total hip joint replacement surgery have the potential to benefit patients [33], particularly in the late post-operative period (>8 weeks) [32]. Similarly, the benefits of physiotherapy exercise 3-4 months after knee joint replacement surgery have been reported in another systematic review [34]. Post discharge rehabilitation after total hip joint replacement has been found to be equally effective when delivered in a centre-based or home-based setting [35].

However, clinicians should judge the suitability of patients to engage in home-based rehabilitation before making such recommendations, and access to outpatient facilities should be made available should a clinical need arise.

Although the evidence is conflicting concerning rehabilitation post discharge, it should be acknowledged that rehabilitation also involves education regarding safety with activities of daily living, self care and self management which are important in the post operative period. Rehabilitation services should be offered to those patients who demonstrate a clinical need for intervention.

Guidelines, Procedures and Protocols

1. Initiate rehabilitation planning at pre-admission clinic.
2. Where clinically appropriate, patients should be mobilised as soon as possible after surgery and initiated on an accelerated rehabilitation pathway.
3. The vast majority of patients after primary joint replacement require little or no physiotherapy after discharge from hospital. However, it is vital that post-discharge outpatient physiotherapy resources should be adequate to identify and treat patients who would benefit from physiotherapy input.
4. Post discharge rehabilitation may be delivered in a centre-based or home environment.
5. Development of policies to enable patients to receive outpatient treatment closer to home.

12. Joint Replacement Registry and Follow up

a. All surgeons performing elective joint replacement surgery should contribute data to the National Joint Replacement Registry.

b. A single state-wide database for the collection of patient outcome data should be established to:

i. monitor the functional status of patients;
ii. ensure that patient expectations are met;
iii. provide an opportunity for further education to optimise self-management practices;
iv. allow the early detection of any post-operative problems;
v. review, quantify and report clinical and radiographic outcomes;
vi. provide opportunities for the collection of powerful longitudinal data which can be used for clinical research and audit purposes;
vii. improve the quality and efficiency of care by utilising data to inform future decision making.

c. It is recommended that a system be created at each hospital site to provide for follow-up of all patients at intervals of 6 months, 12 months, 5 years, 10 years and then 2 yearly thereafter owing to the risk of aseptic prosthesis loosening after 10 years. These timeframes largely align with the recommendations of the Arthroplasty Society of Australia and 10 year local WA Joint Replacement Assessment Clinic (JRAC). This follow-up and data collection may be performed by a physiotherapist or other health professional with delegated authority, while providing the opportunity for findings to be communicated to the surgeon and to involve the surgeon in a follow-up assessment should a clinical need arise. To ensure reliability in the outcome measures collected, particularly if data are intended for use in longitudinal studies, standardised measurement protocols should be made available to sites conducting follow-up evaluations.

d. Follow-up for patients who have undergone joint replacement surgery should occur at the operative hospital. The JRAC model provides an example of an efficient system to enable a timely review of patients with the opportunity to collect important data for clinical and research purposes.

e. Follow-up radiographs should be reviewed by orthopaedic surgeons.

f. Data should remain the property of the treating surgeon.

13. Prosthetics and Technology

Implant tenders for orthopaedics are intended to promote the use of safe and effective implants, and to prevent the use of insufficiently tested implants. At the same time the tender has to be flexible enough to allow the safe introduction of new technology and allow for exceptional individual case needs. This process minimises implant related complications and helps contain costs.

WA Health currently has a poorly functioning implant tender in place for the supply of hip and knee implants in the public system. The prosthetics selection qualifies the implants against standardised criteria, outcomes and costs. There is a need for valid measures for the tender process and ongoing contract monitoring and management through clinical input and the flexibility to change based on new evidence.

Once this tender is revised to a form that is both transparent and acceptable to surgeons, exceptions for the use of implants outside the tender process will need to be made on individual patient basis or part of a clinical trial, not purely on surgeon preference. The tender for WA Health is due for renewal in 2010. Each time the tender is renewed the selection committee should reach decisions of exclusion and inclusion of implants based on the best available evidence, especially data from clinical trials and registry data. The evaluation committee comprises orthopaedic surgeons, bioengineers and scientific officers.

The introduction of new technologies to support joint replacement surgery remains an important initiative to optimise patient care and outcomes. It is important that new technologies are assessed through appropriate channels, such as the Western Australian Policy Advisory Committee on Clinical Practice and Technology (WAPACT), before their introduction into the WA public health system. WAPACT is responsible for considering and making recommendations on the application of new and existing technologies and clinical practices in Western Australian public health services and hospitals. The assessment of surgical innovation, although essential, is a challenging process and should follow a stepwise introduction through the stages of innovation, development, exploration, assessment, and long-term study [36-37].

14. Health Facilities

14.1 Facility Requirements for Orthopaedic Surgery

Joint arthroplasty is a specialised sub-specialty of orthopaedics and requires a high level of facility and support services beyond many other forms of orthopaedic surgery. This surgery is largely performed on an older population and carries a significant risk of complications. The orthopaedic literature provides evidence that achieving best outcomes and minimising adverse events for joint replacement surgery are achieved with dedicated facilities where the surgery is performed by a highly skilled and experienced workforce. Post-operative complication rates after joint replacement surgery are inversely related to both hospital surgical volume [38-42] and surgeon procedure volume [41-42]. A recent systematic review on this topic identified a trend towards increased hospital volume of primary total knee joint replacement significantly reducing patient morbidity and length of stay [43]. Nonetheless, it is acknowledged that definitive conclusions regarding surgeon volume and outcomes are difficult to reaching owing to the diversity in studies reported in the literature. There is evidence from other surgical specialities, for example cardiothoracic surgery, that the disadvantage of low volume activity may be overcome with the introduction of specific evidence-based guidelines or quality measures [44]. Moreover, evaluating clinical practice guidelines at different joint replacement surgery volume hospitals is a critical area for ongoing research [43].

The WA health system adheres to the Australasian Health Facilities Guidelines that sets out the minimum requirements for all health facilities including operating theatres, infection control, sterile supply and layout.

The WA Health Clinical Services Framework 2010-2020 outlines a proposed service delivery plan for orthopaedic surgery, including joint replacement surgery, at metropolitan and regional hospitals. *Routine* elective joint replacement should be undertaken at nominated hospitals, providing they meet clinical and facility requirements outlined in this Model of Care (Table 3). *Complex and revision* joint replacement surgeries should be undertaken at specific specialist centres, such as orthopaedic units within tertiary centres, where clinical and facility resources are extensive, for example, level 5 or 6 care (Table 3). It is envisaged that tertiary hospitals in WA will still perform routine joint replacement surgery, from an orthopaedic perspective. The differentiating factor between routine joint replacement surgery performed at tertiary centres compared to other sites is that patients admitted to tertiary centres are likely to require more complex medical interventions owing to their co-morbidities and higher risks of post-operative complications. Tertiary centres have the levels of medical care required to optimally manage these patients. It is recommended that centres which perform routine elective joint replacement surgeries establish a formalised partnership arrangement with a tertiary or specialist centre to facilitate timely transfers and continuity of appropriate care should complications arise.

In the near future operational activity in public hospitals in WA will be financed on an Activity Based Funding (ABF) model. The ABF model will fund health services according to the type and complexity of the service they provide, as

well as the site in which the service is delivered. In the context of arthroplasty services, funding will be weighted according to the nature and complexity of the surgery such that more complex surgeries will receive a larger funding amount. For example, funding for a primary total hip replacement procedure will be weighted according to the complexity of the case, such that more complex cases which require greater care and a greater length of stay will be funded at a higher amount. Moreover, tertiary hospitals will attract a higher peer group price for a given procedure to reflect the nature of activity provided at a tertiary site, including teaching and research.

Table 3 Proposed clinical and facility requirements for joint replacement surgery in WA general/specialist hospital and tertiary hospital sites.

Resource	Routine surgery (general and specialist hospital sites)	Complex and all revision surgery (tertiary hospital sites)
Medical Cover	• 24 hour 7 days per week • Pain service	• 24 hour 7 days per week • Specialist orthopaedic cover 24/7 • Anaesthetic/pain team 24/7 • General surgery, plastics, urology specialties available
Teaching & Training	• Teaching facilities (registrars, fellows, lecture rooms, offices, research facilities)	• Teaching facilities (registrars, fellows, lecture rooms, offices, research facilities)
Nursing & Allied Health	• Physiotherapy • Occupational therapy • Physiotherapy treatment area and/or gymnasium for rehabilitation • Specialist trained nursing staff	• Specialist nursing • Specialist physiotherapy • Physiotherapy treatment area and gymnasium for rehabilitation • Occupational therapy services • Staff available for outpatient clinic reviews
Outpatient clinics	• OPD clinics for assessment & follow up	• OPD clinics for assessment & follow up
Support Services	• Radiology (X-ray and CT) • Ready access to imaging services (not necessarily on site) MRI, nuclear medicine, CT, PACS, interventional radiology • Immediate access to pathology and laboratory services • Transfusion services	• Radiology including nuclear medicine, X-ray, CT, MRI, PACS availability, interventional radiology • Onsite CSSD • Microbiology • Immediate access to pathology and laboratory services

	• Onsite CSSD	• Transfusion • Bioengineering • Orthotics services
Operating theatre requirements	• Quarantined clean theatres (quarantined from other acute services) • Laminar Flow • Ultraclean air systems • Appropriate facility design to minimise infection risk. • Equipment for immediate and late surgical complications	• Laminar flow • Equipment for revision procedures • Quarantined theatres (quarantined from other acute services) • Ultraclean air systems • Appropriate facility design to minimise infection risk. • Equipment for immediate and late surgical complications
Level of care	• Quarantined from other acute services • Designated high dependency unit (HDU) quarantined from other acute services • Suitable access to intensive care and coronary care unit (off site)	• High Dependency Unit • Designated high dependency unit (HDU) • Suitable access to intensive care and coronary care unit

15. Theatre Efficiency

Guidelines to optimise theatre efficiency have been published by The Association of Anaesthetists of Great Britain and Ireland (2003) and the Australasian Health Facilities Guidelines.

16. Workforce Requirements

A skilled workforce is essential to optimise outcomes for patients undergoing elective joint replacement surgery and ensure sustainability of the service. Workforce requirements include:

- Adequate surgeon, anaesthetist and theatre staff workforce to meet current and projected demand for surgeries.
- Adequate nursing, allied health and hospital support workforce who are appropriately trained to ensure optimal levels of pre and post surgical care, particularly with respect to accelerated rehabilitation pathways.
- Surgeons performing the surgery are appropriately skilled and trained and perform joint replacement on a regular basis. There is some evidence that the rate of adverse surgical events are inversely proportional to individual surgeon procedure volumes [42-43].
- Opportunities must be accommodated across the health system to allow trainees to gain adequate surgical experience. Therefore, opportunities should be provided for trainees to work across tertiary and non-tertiary hospital sites. Although routine joint replacement surgeries will be performed at tertiary sites, it is important that trainees also gain experience in non-tertiary sites where admitted patients are likely to have fewer co-morbidities and post-operative surgical complications.
- Access to microbiology services.
- Medical staff are available on site 24 hours per day.

Telehealth is an effective tool to increase the skills and confidence of clinicians who work in regional and remote sites to provide appropriate care for patients who are discharged from metropolitan-based sites to regional sites [45-46].

17. Teaching and Training

The Royal Australasian College of Surgeons (College) is the principle body for the training and education of surgeons in Australia and New Zealand. Accreditation is given by the Australian Medical Council to the College and the standards for education and training are established by the College. The College collaborates with the Australian Orthopaedic Association (AOA) to administer the training program. There is a contract and memorandum of understanding between the College and the AOA to enable the AOA to run orthopaedic training programmes as an agent for the College.

A level of credentialing is necessary to perform any orthopaedic surgical procedure. Credentialing to perform routine orthopaedic surgeries, including primary joint replacement surgery, is accepted with attainment of FRACS (Ortho). This recognises the role of the AOA in the maintenance of training quality throughout Australia. Each surgeon's credentials are recorded in their scope of clinical practice at each hospital site at which they operate. Surgeons are expected to operate only within their scope of clinical practice, defined in accordance with the relevant polices of the Department of Health, administered through the Office of Safety and Quality in Healthcare [47].

Credentialing to perform certain complex and revision orthopaedic surgeries, that is surgery beyond primary total joint replacement surgery, requires training above the attainment of FRACS (Ortho). Although surgeons may be accredited to perform orthopaedic surgery in line with FRACS (Ortho), their scope of clinical practice, needs to be extended for them to be credentialed to perform some complex and revision orthopaedic surgeries. It is the responsibility of the area wide or institutional credentialing committee to approve an extension of s surgeon's scope of clinical practice.

Similarly, nursing and allied health staff should be appropriately accredited through their respective registration boards and maintain a minimum set of competencies to work safely in an orthopaedic unit.

Research opportunities should be facilitated and encouraged at major joint replacement centres in WA.

18. Recommendations

A set of key recommendations have been developed for the Elective Joint Replacement Service Model of Care. Implementation of these recommendations across area health services must be considered in the context of operational factors at a local level and Activity Based Funding priorities for WA Health. The recommendations include:

1. **Referral Pathway**
   - **a.** An electronic referral pathway should be established for patients to access outpatient orthopaedic clinics after primary assessment by a GP. The electronic pathway system should interface with existing practice software used by GPs.
   - **b.** General Practitioners should ideally use the state-wide standard prioritisation and assessment criteria (eg CPAC for Orthopaedics) and provide standardised radiographs and a surgical prioritisation score.
   - **c.** All referrals for orthopaedic assessment should be triaged by a suitably qualified triage officer using standardised protocols.
   - **d.** State-wide patient record numbers should be adopted to minimise duplication of medical records and diagnostic tests.
   - **e.** Multidisciplinary pre-admission assessment should occur prior to surgery with sufficient time for team members to act upon any issues raised during the assessment. The assessment should include:
     - i. Surgical team review
     - ii. Nursing review and information provided about infection control protocols
     - iii. Anaesthetic and fitness for surgery review
     - iv. Physiotherapy assessment
     - v. Occupational Therapy assessment including functional review
     - vi. Social Work assessment
     - vii. Discharge and post operative care planning.
   - **f.** Utilise a screening tool at pre-admission clinic to identify modifiable physical and psychosocial factors which are known to increase length of stay and/or contribute to poorer post-operative outcomes. Pre-operative education and rehabilitation services should be offered to patients where these modifiable factors are identified.

2. **Patient Information**
   - **a.** Standardised or minimum criteria patient information/education should be developed or endorsed to ensure quality and consistency between centres providing elective joint replacement services. Information in languages other than English should also be made available.

3. **Facilities**
   a. Identification of suitable centres for elective primary and revision joint replacement surgery in WA to provide the highest standards of joint replacement outcomes, teaching and research.
   b. Dedicated centres should be identified for primary and complex/revision surgery and contain appropriate staff, equipment and facilities to deal with the surgery that is being performed at the site. Throughput at these sites should be adequate to maintain expertise of staff and minimise adverse events.
4. **Procedure**
   a. Guidelines for prophylaxis to minimise thromboembolic and peri-prosthetic infection should be made available, and based on best evidence.
   b. Criteria-led discharge protocols should be introduced for primary total hip and total knee joint replacement surgery to ensure consistency of care between sites while addressing operational requirements.
   c. Patients are admitted on the day of surgery.
   d. Patients' planned procedures are not cancelled.
   e. Pain team should be involved in the peri-operative period.
   f. Patients with routine primary joint replacements are mobilised as soon as possible after surgery.
5. **Joint Replacement Registry and follow up**
   a. All surgeons performing elective joint replacement surgery should contribute data to the National Joint Replacement Registry.
   b. A single state-wide database for the collection of patient outcome data should be established to:
      i. monitor the functional status of patients;
      ii. ensure that patient expectations are met;
      iii. provide an opportunity for further education to optimise self-management practices;
      iv. allow the early detection of any post-operative problems;
      v. review, quantify and report clinical and radiographic outcomes;
      vi. provide opportunities for the collection of powerful longitudinal data which can be used for clinical research and audit purposes;
      vii. improve the quality and efficiency of care by utilising data to inform future decision making.
   c. It is recommended that a system be created at each hospital site to provide for follow-up of all patients at intervals of 3 months, 12 months, 5 years, 10 years and then 2 yearly thereafter owing to the risk of aseptic prosthesis loosening after 10 years. These timeframes largely align with the recommendations of the Arthroplasty Society of Australia and 10 year local WA Joint Replacement Assessment Clinic (JRAC). This follow-up and data collection may be performed by a physiotherapist or other health professional with delegated authority, while providing the opportunity for findings to be communicated to the

surgeon and to involve the surgeon in a follow-up assessment should a clinical need arise. To ensure reliability in the outcome measures collected, particularly if data are intended for use in longitudinal studies, standardised measurement protocols should be made available to sites conducting follow-up evaluations.

d. Follow-up for patients who have undergone joint replacement surgery should occur at the operative hospital. The JRAC model provides an example of an efficient system to enable a timely review of patients with the opportunity to collect important data for clinical and research purposes.

e. Follow-up radiographs should be reviewed by orthopaedic surgeons.

f. Data should remain the property of the treating surgeon.

6. Discharge Pathway

a. At discharge, a summary should be immediately sent to the referring GP which describes the surgical procedure performed, outcomes, and post-operative care for the patient. Ideally, the discharge summary should be sent electronically.

b. Post-operative care services for the period after discharge should be arranged by hospital staff.

7. Workforce

a. Surgeons performing joint replacement should only operate within their defined scope of practice and maintain their skills through peer reviewed audit and continued professional development.

b. Research and multidisciplinary workforce development opportunities should be facilitated and encouraged by centres where elective joint replacement surgery is undertaken.

c. Opportunities should be made available for surgical trainees to work across an area health service in both tertiary and non-tertiary hospital sites.

8. Prosthetics

a. A revised and acceptable tender for prostheses should be developed based on best evidence, and enforced in public hospitals. Exceptions for the use of implants outside the tender process should be made on an individual patient basis or part of a clinical trial, rather than purely on surgeon preference.

b. Any new technologies for joint replacement surgery should be assessed through an appropriate body such as the Western Australian Policy Advisory Committee on Clinical Practice and Technology (WAPACT) before their introduction into the WA public health system.

9. Radiology

a. A standardised state-wide system of electronic linkage between the public and private radiology providers should be established to enable timely access to diagnostics, reduce duplication of radiographs, minimise cost, avoid unnecessary exposure to ionising radiation and facilitate audit and research.

References

1. Australian Bureau of Statistics. 1995 National Health Survey. Canberra: ABS; 1996.
2. Australian Orthopaedic Association National Joint Replacement Registry. Annual Report. Adelaide: AOA; 2009.
3. Graves SE, Davidson D, Ingerson L, et al. The Australian Orthopaedic Association National Joint Replacement Registry. Medical Journal of Australia 2004;180:S31-S4.
4. March LM, Bagga H. Epidemiology of osteoarthritis in Australia. Medical Journal of Australia 2004;180:S6-S10.
5. Cushnaghan J, Bennett J, Reading I, et al. Long-term outcome following total knee arthroplasty: a controlled longitudinal study. Annals of the Rheumatic Diseases 2009;68:642-7.
6. Naylor JM, Harmer AR, Heard RC, Harris IA. Patterns of recovery following knee and hip replacement in an Australian cohort. Australian Health Review 2009;33:124-35.
7. Burns AWR, Bourne RB, Chesworth BM, MacDonald SJ, Rorabeck CH. Cost effectiveness of revision total knee arthroplasty. Clinical Orthopaedics and Related Research 2006:29-33.
8. Mahomed NN, Barrett JA, Katz JN, et al. Rates and outcomes of primary and revision total hip replacement in the United States Medicare population. Journal of Bone and Joint Surgery-American Volume 2003;85A:27-32.
9. Patil S, Garbuz DS, Greidanus NV, Masri BA, Duncan CP. Quality of life outcomes in revision vs primary total hip arthroplasty. Journal of Arthroplasty 2008;23:550-3.
10. Lubbeke A, Katz JN, Perneger TV, Hoffmeyer P. Primary and revision hip arthroplasty: 5-year outcomes and influence of age and comorbidity. Journal of Rheumatology 2007;34:394-400.
11. Dixon T, Shaw M, Ebrahim S, Dieppe P. Trends in hip and knee joint replacement: socioeconomic inequalities and projections of need. Annals of the Rheumatic Diseases 2004;63:825-30.
12. Nilsdotter AK, Lohmander LS. Age and waiting time as predictors of outcome after total hip replacement for osteoarthritis. Rheumatology 2002;41.
13. Ackerman IN, Graves SE, Wicks IP, Bennell KL, Osborne RH. Severely compromised quality of life in women and those of lower socioeconomic status waiting for joint replacement surgery. Arthritis & Rheumatism-Arthritis Care & Research 2005;53:653-8.
14. Conner-Spady BL, Johnston GH, Sanmartin C, McGurran JJ, Noseworthy TW, Gr SWREW. A bird can't fly on one wing: patient views on waiting for hip and knee replacement surgery. Health Expectations 2007;10:108-16.
15. Hoogeboom TJ, van den Ende CHM, van der Sluis G, et al. The impact of waiting for total joint replacement on pain and functional status: A systematic review. Osteoarthritis and Cartilage 2009;17:1420-7.
16. Davis AM, Agnidis Z, Badley E, et al. Waiting for hip revision surgery: the impact on patient disability. Canadian Journal of Surgery 2008;51:92-6.
17. National Health Service Institute for Innovation and Improvement. Delivering Quality and Value. Focus on: Primary Hip and Knee Replacement. Nottingham: NHS; 2006.

18. Scott JF, Morgan G, Avent M, Graves S, Goss AN. Patients with artificial joints: do they need antibiotic cover for dental treatment? Australian Dental Journal 2005;50:S45-S53.
19. Dawson J, Fitzpatrick R, Carr A, Murray D. Questionnaire on the perceptions of patients about total hip replacement. J Bone Joint Surg (British) 1996;78B:185-90.
20. Dawson J, Fitzpatrick R, Murray D, Carr A. Questionnaire on the perceptions of patients about total knee replacement. J Bone Joint Surg (British) 1997;80B:63-9.
21. Department of Human Services. Orthopaedic Waiting List Project. Summary Report. Melbourne: Government of Victoria; 2006.
22. Department of Health Western Australia. Consent to treatment policy for the Western Australian health system. Perth: Office of Safety and Quality, Department of Health (WA); 2009.
23. McDonald S, Hetrick SE, Green S. Pre-operative education for hip or knee replacement. Cochrane Database of Systematic Reviews 2004:Article CD003526.
24. Ackerman IN, Bennell KL. Does pre-operative physiotherapy improve outcomes from lower limb joint replacement surgery? A systematic review. Australian Journal of Physiotherapy 2004;50:25-30.
25. Sharma V, Morgan PM, Cheng EY. Factors influencing early rehabilitation after THA: A systematic review. Clinical Orthopaedics and Related Research 2009;467:1400-11.
26. Chong BH, Braithwaite J, Harris MF, Fletcher JP. Venous thromboembolism - A major health and financial burden: How can we do better to prevent this disease? Medical Journal of Australia 2008183:134-5.
27. Schumock GT, Blackburn JC, Nwesicu EA, Walton SM, Finley JM, Lewis RK. Impact of prescribing guidelines for inpatient anticoagulation. Annals of Pharmacotherapy 2004;38:1570-5.
28. Barbieri A, Vanhaechtk K, Van Herck P, et al. Effects of clinical pathways in the joint replacement: a meta-analysis. BMC Medicine 2009;7.
29. Khan F, Ng L, Gonzalez S, Hale T, Turner-Stokes L. Multidisciplinary rehabilitation programmes following joint replacement at the hip and knee in chronic arthropathy. Cochrane Database of Systematic Reviews 2008.
30. Mahomed NN, Davis AM, Hawker G, et al. Inpatient compared with home-based rehabilitation following primary unilateral total hip or knee replacement: A randomized controlled trial. Journal of Bone and Joint Surgery-American Volume 2008;90A:1673-80.
31. Muller E, Mittag O, Gulich M, Uhlmann A, Jackel WH. Systematic literature analysis on therapies applied in rehabilitation of hip and hnee arthroplasty: Methods, results and challenges. Rehabilitation 2009;48:62-72.
32. Di Monaco M, Vallero F, Tappero R, Cavanna A. Rehabilitation after total hip arthroplasty: a systematic review of controlled trials on physical exercise programs. European Journal of Physical and Rehabilitation Medicine 2009;45:303-17.
33. Lowe CJM, Barker KL, Dewey ME, Sackley CM. Effectiveness of physiotherapy exercise following hip arthroplasty for osteoarthritis: a systematic review of clinical trials. BMC Musculoskeletal Disorders 2009;10.

34. Lowe CJM, Barker KL, Dewey M, Sackley CM. Effectiveness of physiotherapy exercise after knee arthroplasty for osteoarthritis: systematic review and meta-analysis of randomised controlled trials. British Medical Journal 2007;335:812-5.
35. Galea MP, Levinger P, Lythgo N, et al. A targeted home- and center-based exercise program for people after total hip replacement: A randomized clinical trial. Archives of Physical Medicine and Rehabilitation 2008;89:1442-7.
36. McCulloch P, Altman DG, Campbell WB, et al. No surgical innovation without evaluation: the IDEAL recommendations. Lancet 2009;374:1105-12.
37. Malchau H. Introducing new technology: A stepwise algorithm - Editorial comments. Spine 2000;25:285-.
38. Geubbels ELPE, Willie JC, Nagelkerke NJD, Vandenbroucke-Grauls CMJE, Grobbee DE, de Boer AS. Hospital-related determinants for surgical-site infection following hip arthroplasty. Infec Contron Hosp Epidemiol 2005;26:435-41.
39. Cram P, Vaughan-Sarrazin MS, Wolf B, Katz JN, Rosenthal GE. A comparison of total hip and knee replacement in specialty and general hospitals. Journal of Bone and Joint Surgery-American Volume 2007;89A:1675-84.
40. Judge A, Chard J, Learmonth I, Dieppe P. The effects of surgical volumes and training centre status on outcomes following total joint replacement: analysis of the Hospital Episode Statistics for England. Journal of Public Health 2006;28:116-24.
41. Katz JN, Barrett J, Mahomed NN, Baron JA, Wright J, Losina E. Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. Journal of Bone and Joint Surgery-American Volume 2004;86A:1909-16.
42. Shervin N, Rubash HE, Katz JN. Orthopaedic procedure volume and patient outcomes - A systematic literature review. Clinical Orthopaedics and Related Research 2007:35-41.
43. Marlow NE, Barraclough B, Collier NA, et al. Centralization and the relationship between volume and outcome in knee arthroplasty procedures. Australian and New Zealand Journal of Surgery 2010;80:234-41.
44. Auerbach AD, Hilton JF, Maselli J, Pekow PS, Rothberg MB, Lindenauer PK. Shop for Quality or Volume? Volume, Quality, and Outcomes of Coronary Artery Bypass Surgery. Annals of Internal Medicine 2009;150:696-704.
45. Marie B, Kaan A, Ignaszewski A, Lear SA. A systematic review of telemonitoring technologies in heart failure. European Journal of Heart Failure 2009;11:506-17.
46. Verhoeven F, van Gemert-Pijnen L, Dijkstra K, Nijland NN, Seydel E, Steehouder M. The contribution of teleconsultation and videoconferencing to diabetes care: A systematic literature review. Journal of Medical Internet Research 2007;9.
47. Department of Health Western Australia. The Policy for Credentialling and Defining the Scope of Clinical Practice for Medical Practitioners (2nd edition). Perth: Office of Safety and Quality, Department of Health (WA); 2009.

Appendices

Appendix 1. Patient Blood Management Guidelines

What is Patient Blood Management?

Patient blood management (PBM) views a patient's own blood as a valuable and unique natural resource that should be conserved and managed appropriately. Altruistically donated allogeneic blood, given in trust, is a valuable community resource. Accordingly, it should be used only as therapy with patient consent when there is evidence for potential benefit, there are no alternatives, and the risks are appropriately considered and balanced against the benefits.

PBM is seen as the new paradigm in transfusion medicine.[1] It employs a patient-specific perioperative, multidisciplinary, multimodal team approach to optimising, conserving and managing the patient's own blood. It aims to identify patients at risk of transfusion and provide a management plan aimed at reducing or eliminating the need for allogeneic transfusion.[2-4] The Austrian benchmark study demonstrated that 98% of all transfusions could be predicted by three factors: 1) pre-operative anaemia, 2) volume of surgical blood loss and, 3) failure to adopt a more conservative haemoglobin threshold for transfusion.[5]

Strategies to address these risk factors are referred to as the three pillars of patient blood management:[5, 6]

1. Optimise the patient's red cell mass
2. Minimise blood loss
3. Harness and optimise the physiological tolerance of anaemia (including restrictive transfusion thresholds)

This is accomplished in three integrated phases:

1. Pre-operative assessment, work-up and planning
2. Intra-operative surgical, anaesthetic, technological and pharmacological strategies
3. Post-operative blood conservation, maximising recovery of blood elements and providing optimum support

Rationale For Patient Blood Management

There are compelling reasons for implementing patient blood management including:

Blood supply issues

Changing population dynamics present significant challenges for blood product inventory. Western Australia data show a significantly higher per-capita blood utilisation in the older patient segments than in the younger.[7] Patients aged 70 years and over received 179.6 red blood cells (RBC) units per 1000 population compared with 33.5 in the 40–69 years age bracket and only 10.7 in the 0–39 years age bracket. The overall RBC utilisation in the 70 years and over age segment accounted for more than 45% of all RBCs transfused.

Population modelling for Western Australia shows that the over 65 years age bracket will increase by 146% from 1997 to 2026, whereas the population aged 64 years or less, which includes the age range eligible to donate blood, will only increase by 38%.[8] Therefore, WA has a fast growing, heavy blood-using but non-donating segment of the population dependent upon a slow growing donor base. This will put increasing pressure on supply.

Cost of blood

The burgeoning total cost of blood is becoming unsustainable. The direct cost of blood products has progressively increased as a result of improved collection, testing and processing.[9, 10] However, the process cost of administering the transfusion within the hospital may be 2 to 5 times that of the product cost.[11] A recent Australian study demonstrated that the cost of transfusion of a single unit of RBCs, including acquisition costs, was AU$700.[1] Additionally, if all transfusion related costs are calculated, including short-term and suspected mid- and long-term adverse effects, the total cost of RBC transfusion may represent up to 5% of the total public healthcare budget of some high human development index countries.[12]

Transfusion practice variability

Wide variations in transfusion practice exist between countries, institutions and even between individual clinicians within the same institution.[5, 13] The National Health and Medical Research Council (NHMRC) and Australasian Society of Blood Transfusion (ASBT) Clinical Practice Guidelines for Blood and Blood Components (2001) refer to studies estimating that between 16-50% of RBC transfusions in Australia may be inappropriate.[14] The 2005 *Towards Better, Safer Blood Transfusion: A Report for the Australian Council for Safety and Quality in Health Care* reported "a failure of contemporary Australian transfusion practices to align with recommended best practice."[15] The report stated: "Overuse of blood products is common and under use is rare." Two recent Australian papers by Grey et al[16] and Daly et al[17] revealed that marked variations in transfusion practice persist, highlighting poor clinician understanding of appropriate blood usage.

Transfusion safety and effectiveness

While blood transfusion may be life-saving in the setting of critical bleeding, it is also associated with significant risk. Although the risk of known infectious agents such as HIV, HCV and HBV has been reduced to very low levels, the blood supply remains vulnerable to emerging infectious agents.[18] Transfusion-associated circulatory overload (TACO), transfusion-related acute lung injury (TRALI), wrong blood component transfused, acute transfusion reactions and bacterial contamination of blood remain the leading causes of transfusion-related death and major morbidity.[19] Of increasing concern is the growing body of literature suggesting that transfusion *per se* is a risk factor for increased mortality, ICU admission and increased hospital length of stay and morbidity including increased incidence of infection, septicaemia, ischaemic events (including stroke, myocardial infarction and renal impairment/failure), thromboembolism, multisystem organ failure, systemic inflammatory response syndrome and acute respiratory distress syndrome.[1, 20-23] This demands a more judicious approach to weighing risks versus benefits prior to transfusion,

particularly in the light of emerging evidence that, in many settings, studies have been unable to demonstrate effectiveness where it has traditionally been assumed that transfusions benefit patients.[21, 24, 25]

Accordingly, efforts should be directed at minimising or avoiding transfusions wherever possible.

The Perioperative Multidisciplinary Multimodal Approach to Patient Blood Management

Much has been written in the literature and in textbooks about this integrated approach to patient blood management in joint replacement and other major surgery.[3, 4, 6, 26-33] Strategies, guidelines and algorithms have been developed to assist in this multimodal approach.[34-36] An overview of the integrated approach to patient blood management is here provided. A more extensive document along with support information will be available on the WA Patient Blood Management website.

1. Pre-operative Phase

Pre-operative assessment and preparation requires formulating a treatment plan specific to the procedure required and the condition of the patient. It includes comparing the estimated perioperative blood loss (or anticipated post-operative haemoglobin fall) for that particular procedure, with the calculated patient-specific tolerable blood loss (or haemoglobin fall), taking into consideration their age, weight, height, gender, commencement haemoglobin and co-morbidities such as cardiovascular or pulmonary disease. Formulae have been developed for this calculation.[37, 38] If the estimated blood loss is greater than the tolerable blood loss, then strategies should be considered to optimise the patient's physiological condition, reduce blood loss and/or increase the patient's red blood cell mass.

Identify, evaluate and manage anaemia/iron deficiency

Pre-operative anaemia is associated with increased morbidity, hospital length of stay, mortality[39-41] and healthcare costs[42] and has been shown to have an impact on post-operative functional recovery[43-45] and quality of life after orthopaedic surgery.[46] Pre-operative anaemia also increases the likelihood of transfusion.[5, 47, 48] Haemoglobin levels <130 g/L can increase the risk of transfusion from 2- to 9-fold.[49] Transfusion to treat anaemia, however, is independently associated with increased morbidity, mortality and hospital length of stay.[20, 23, 39, 50]

Pre-operative anaemia has been reported in 18-46% of patients presenting for orthopaedic surgery.[41, 48] Iron, B12 and folate deficiencies with or without anaemia are frequent, particularly among the elderly population, and may compromise patients' ability to recover their haemoglobin following surgery.[51-55]

In patients undergoing elective joint replacement surgery pre-operative anaemia, iron deficiency and suboptimal iron stores should be identified, evaluated and managed to minimise RBC transfusion. Patients should be evaluated as early as possible to coordinate scheduling of surgery with optimisation of the patient's haemoglobin and iron stores.[56]

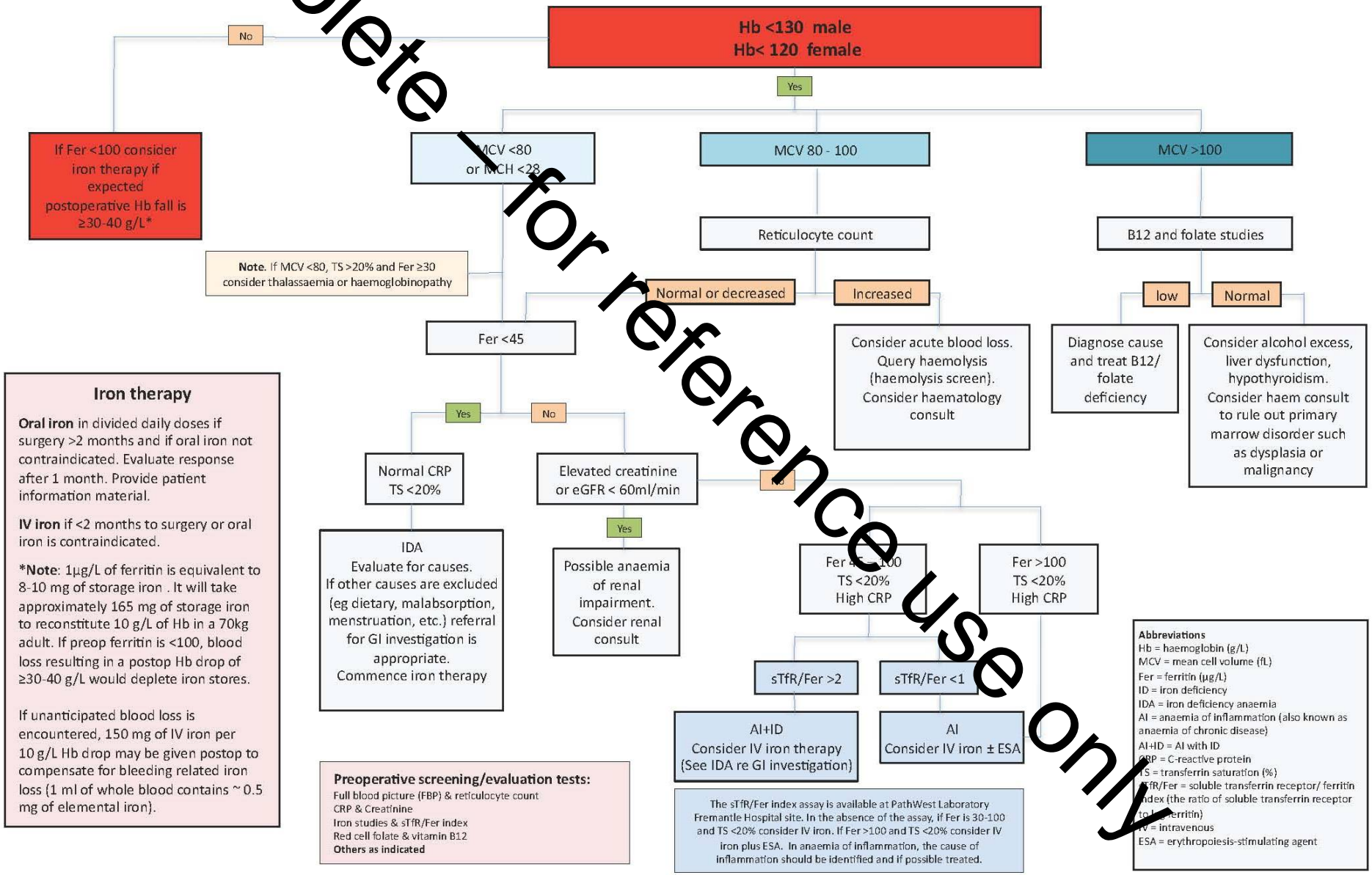
An algorithm for pre-operative anaemia/iron status evaluation is included as Table 1. It is not a definitive anaemia diagnosis pathway, but rather a guide to enable optimisation of patients' haemoglobin and iron stores ahead of elective joint replacement surgery. This evaluation should be part of the patient's overall pre-operative assessment and should take into account the patient's history, clinical assessment and nature of proposed surgical procedure including likelihood for significant blood loss. *As anaemia may be a result of serious underlying pathology, the aetiology should always be identified. Some findings may require specialist consultation or referral to diagnose and treat the cause*.[57]

The two most common types of anaemia affecting surgical patients are iron deficiency anaemia and anaemia of inflammation, also known as anaemia of chronic disease. Table 2 lists indices that can assist in differentiating between iron deficiency anaemia, anaemia of inflammation and a combination of the two. Definitive diagnosis is important in order to provide the most effective treatment [58-60] which may include oral or intravenous (IV) iron, other haematinics and possible selective use of erythopoiesis stimulating agents (ESAs).[52, 61-72] Clinicians need to be aware that there are numerous factors, often present in surgical patients, that can inhibit or block oral iron absorption and iron availability for erythropoiesis.[73] See Table 3 for a summary of iron physiology.

Non-anaemic patients undergoing surgery with significant blood loss may not have sufficient iron stores to recover their haemoglobin post-operatively. It is estimated that 1 µg/L of ferritin is equivalent to about 8 mg of storage iron in a 70 kg patient (or 120 µg storage iron/kg body weight).[74-76] It takes approximately 165 mg of storage iron to reconstitute 10 g/L of Hb in a 70 kg adult (corresponding to ~20 µg/L of ferritin). If a surgical procedure results in a Hb fall of 30-40 g/L, the predicted drop in ferritin would be 60-80 µg/L. So, if the patient's pre-operative ferritin is <100 µg/L, iron stores would be insufficient to reconstitute their Hb loss and maintain normal iron stores (ferritin >45 µg/L).[77] Thus, pre-operative iron therapy may be indicated in non-anaemic patients with a pre-operative ferritin <100 µg/L and an anticipated post-operative Hb fall of ≥30-40 g/L.[52, 67, 78]

Table 1. Preoperative anaemia/iron deficiency detection, evaluation & management

Use of this algorithm should always take into account the patient's history, clinical assessment and nature of proposed surgical procedure



Iron therapy

Oral iron in divided daily doses if surgery >2 months and if oral iron not contraindicated. Evaluate response after 1 month. Provide patient information material.

IV iron if <2 months to surgery or oral iron is contraindicated.

***Note**: 1µg/L of ferritin is equivalent to 8-10 mg of storage iron . It will take approximately 165 mg of storage iron to reconstitute 10 g/L of Hb in a 70kg adult. If preop ferritin is <100, blood loss resulting in a postop Hb drop of ≥30-40 g/L would deplete iron stores.

If unanticipated blood loss is encountered, 150 mg of IV iron per 10 g/L Hb drop may be given postop to compensate for bleeding related iron loss (1 ml of whole blood contains ~ 0.5 mg of elemental iron).

Preoperative screening/evaluation tests:
Full blood picture (FBP) & reticulocyte count
CRP & Creatinine
Iron studies & sTfR/Fer index
Red cell folate & vitamin B12
Others as indicated

The sTfR/Fer index assay is available at PathWest Laboratory Fremantle Hospital site. In the absence of the assay, if Fer is 30-100 and TS <20% consider IV iron. If Fer >100 and TS <20% consider IV iron plus ESA. In anaemia of inflammation, the cause of inflammation should be identified and if possible treated.

Abbreviations
Hb = haemoglobin (g/L)
MCV = mean cell volume (fL)
Fer = ferritin (µg/L)
ID = iron deficiency
IDA = iron deficiency anaemia
AI = anaemia of inflammation (also known as anaemia of chronic disease)
AI+ID = AI with ID
CRP = C-reactive protein
TS = transferrin saturation (%)
sTfR/Fer = soluble transferrin receptor/ ferritin index (the ratio of soluble transferrin receptor to ferritin)
IV = intravenous
ESA = erythropoiesis-stimulating agent

Anaemia/iron Deficiency Recommendations

- Once the decision to treat surgically has been made, patients should be screened for anaemia/iron deficiency at either the orthopaedic clinic or the pre-admission clinic to facilitate timely evaluation and management
- The screen should include: 1) full blood picture (FBP) and reticulocyte count; 2) C-reactive protein (CRP) and creatinine; 3) iron studies and soluble transferrin receptor index (sTfR/Fer); and 4) red cell folate and vitamin B12*
  - Pre-operative anaemia = Hb < 120 g/L in females and Hb <130 g/L in males (as defined by WHO)
  - Suboptimal iron stores in non-anaemic patients facing surgery with significant blood loss = ferritin <100 µg/L
- Provide patient with Patient Blood Management Factsheet and Iron Therapy Brochure (available from the PBM website)
- The cause of anaemia should be identified and, wherever possible, treated and the haemoglobin/iron stores optimised
- Care teams should appoint an appropriately qualified person to coordinate the evaluation and management of anaemia/iron deficiency in patients either by their GP or the multidisciplinary team and, in waitlisted patients, the timely review of response to therapy
- If > 2 months to surgery and CRP is not significantly elevated, a trial of oral iron, B12 and folate, followed by review of response
- If < 2 months to surgery, consideration should be given to IV iron and other appropriate therapy
- A number of options could be considered for IV iron infusions including the same day unit, private clinic or GP clinic infusion centres, and opportunities to utilise nurse practitioners.

* Only two samples are required to perform these tests, preferably collected in small volume (eg. 2 mL) tubes. The two assays in each group combine into a single CMBS item number when ordered together.

Identify ways to reduce surgical bleeding:[79]

A good medical and bleeding history is very important in assessing operative bleeding risk related to both inherited and acquired haemostatic disorders.

Liver and renal function tests, INR, APTT, TCT and platelet function studies may be useful in identifying compromised haemostasis. However, if these investigations don't provide the diagnosis then referral to a haematologist should be considered and the surgery delayed.

Identify medications and herbal/vitamin supplements that may cause an increase in operative bleeding and that may need to be discontinued, substituted or dose modified:

- Medications include specific platelet function inhibitors such as aspirin and clopidogrel, and other drugs including NSAIDs, anticoagulants, beta-lactam antibiotics and some cardiovascular and psychotropic drugs.
- Herbals/vitamins: Garlic, St Johns wort (hypericum), feverfew, ginkgo biloba, ginger, ginseng, fish oil, vitamin E and others.[79, 80]

Vitamin K may correct coagulation disorders associated with current or recent use of beta-lactam antibiotics, poor diet, malabsorption and liver dysfunction. Acute and chronic renal failure may be associated with platelet dysfunction that can be reversed with DDAVP and/or cryoprecipitate.

DDAVP can be used to treat mild haemophilia and von Willebrand's disease. (Note: DDAVP is contraindicated in Type IIb von Willebrand's disease)

The antifibrinolytic agent tranexamic acid has been shown to significantly reduce perioperative blood loss and transfusion usage and contribute to cost savings.[81-84]

Pre-operative autologous donation

Pre-operative autologous blood donation (PAD) is now generally not recommended unless the clinical circumstances are exceptional.[85] Its efficacy and cost-effectiveness have been questioned. Other, more cost-effective, autologous blood options are available such as acute normovolaemic haemodilution and intra- and post-operative cell salvage.[86-88]

Patient consent

Informed consent/refusal in relation to blood transfusion is now a hospital accreditation requirement in Australia. The Consent to Treatment Policy for the West Australian Health System[90] states that "Informed consent for blood transfusion means a dialogue has occurred between the patient and doctor. The significant risks, benefits and alternatives to transfusion including the patient's right to refuse the transfusion will have been discussed". It adds that the risks of any adverse outcomes discussed with the patient should be recorded in the patient's medical records. Furthermore it adds that, ideally, the health professional should also provide the patient with appropriate written information and suggests that resources developed by the NHMRC/ASBT and the ARCBS may be useful.

2. Intra-operative Phase

The intra-operative phase requires good planning and close communication and cooperation between all personnel involved. Factors that help in reduction of blood loss include:

Surgical considerations

A crucial factor in surgical blood loss reduction is the meticulous nature of haemostasis required during surgical dissection and procedure. The Austrian Benchmark study found wide inter-centre variability in blood loss for identical procedures contributing significantly to variations in transfusion usage.[5] Surgeons need to be aware of surgical practice, techniques and devices that can reduce blood loss.

Good organisation, communication and proficiency of surgical assistants, theatre nurses and other theatre personnel can contribute to saving operative time and reducing blood loss.

Anaesthetic considerations

Anaesthetic interventions can contribute to modifying blood loss and improving the surgical field, which in turn may contribute to further blood loss reduction. Anaesthetists should be aware of the possible contribution of spontaneous ventilation (versus positive pressure ventilation), controlled hypotension and regional anaesthesia in reducing blood loss. [91-95]

Intra-operative autologous blood options

Acute normovolaemic haemodilution (ANH) has been used as an alternative to PAD.[96] It is most effective as a blood conserving method in patients at risk of significant blood loss, when combined with other blood conservation strategies, when the patient's haemoglobin has been optimised pre-operatively and when a sufficient volume of blood is withdrawn (at least 1000 mL in an adult). [4, 97-102] Other advantages of ANH have been reported. In a randomised controlled trial comparing ANH with "standard transfusion" in patients undergoing elective hip surgery ANH patients had significantly reduced infection rates, antibiotic use and hospital length of stay.[103]

Intra-operative cell salvage is a cost-effective autologous blood option in procedures with an expected significant blood loss.[96, 104, 105] Good quality assurance is needed to optimise the volume and quality of the RBCs recovered.[106] When used appropriately, this technique facilitates the recovery and readministration of several blood volumes of RBCs.[107] Packs may be washed to salvage absorbed blood, further optimising return.[108]

The combination of ANH and cell salvage appears to be even more effective than when these modalities are used individually and makes possible the reduction or even complete avoidance of allogeneic transfusion in very large blood loss procedures.[109, 110]

Topical Haemostatic Agents

A wide variety of topical haemostats, sealants, adhesives and gels are now available to assist with reducing blood loss. [111] Studies suggest some of these may contribute to reducing blood loss and transfusion in knee replacement surgery[112-115] but less so in hip replacement surgery.[116-118]

Other considerations

Perioperative maintenance of normothermia has been shown to reduce blood loss and transfusion.[119-122] A meta-analysis by Rajagopalan et al found that even mild hypothermia significantly increased the risk of blood loss and transfusion.[123]

Fluid choice and use may impact on blood loss and patient outcome.[4, 124, 125]

3. Post-operative Phase

There are a number of therapeutic manoeuvres that can be used in the post-operative period to minimise blood loss and maximise the patient's blood production.

Minimise blood loss

Blood loss may be minimised through adequate oxygenation, avoiding hypertension, maintaining normothermia and being conscious of drug interactions that may increase bleeding and iatrogenic anaemia.

As blood sampling can contribute to transfusion exposure, attention to the frequency and volume of blood sampling is important, particularly in patients admitted to ICU[126-128] or having a prolonged hospital stay.[129] Minimal volume sampling techniques along with non-invasive monitoring and careful planning of tests can significantly reduce iatrogenic blood loss.[130]

Active blood loss management may also include appropriate salvage and reinfusion of drain blood[131-136] and the use of pharmacological agents to assist haemostasis.[137]

Adopting a lower transfusion threshold

Current evidence suggests that a restrictive transfusion threshold is safe and reduces transfusion usage. The decision to transfuse should not be based solely on a haemoglobin value, but rather a careful, patient-specific assessment of clinical status.

- Transfusion is generally not indicated in asymptomatic, non-bleeding patients when the haemoglobin level is ≥80 g/L.
- In non-bleeding patients red blood cells should be transfused one unit at a time followed by clinical assessment of benefit and further need.
- Post-operative hypotension may be related to continuing pre-operatively administered hypotensive drugs and diuretics. In elderly patients, especially, post-operative medication requirements may require daily review.

Evidence for restrictive red blood cell transfusion threshold

For several decades a haemoglobin level of <100 g/L was used as the transfusion trigger (the threshold that triggers the decision to transfuse a patient). In the late 1980s this was challenged as dogma and shown not to be based on science.[138, 139]

Most published guidelines,[79, 140, 141] including the NHMRC / ASBT Clinical Practice Guidelines on the Use of Blood and Blood Components (2001),[14] now recommend a transfusion trigger of around <60 to <70 g/L for most relatively stable non-bleeding patients. They also note that lower thresholds may be acceptable in some patients who are asymptomatic and/or where other specific therapy is available.

Transfusing a patient with a haemoglobin level >70g/L may be appropriate if there is evidence of ischaemia, ongoing blood loss and/or other risk factors, however, the guidelines unanimously maintain that transfusion in patients with haemoglobin levels greater than 100 g/L is not indicated.

Based on a systematic review and analysis of all literature published over 13 years on transfusion and outcomes, the International Consensus Conference on Transfusion and Outcomes (ICCTO) found that there is little evidence to support transfusion improving patient outcomes in relatively stable non-bleeding patients when the haemoglobin is ≥80 g/L.[142]

Recent studies in patients with acute myocardial infarction and acute coronary syndromes demonstrate some benefit from transfusion when the haemoglobin level is <80 g/L, a mixture of a neutral effect and a harmful effect of transfusion when the

haemoglobin is between 80 to 90 g/L, and a harmful effect from transfusion when the haemoglobin is >90 g/L.[143-145]

A large randomised controlled trial of transfusion thresholds in critically ill adult patients found that a transfusion trigger of <70 g/L and a target maintenance haemoglobin of between 70-90 g/L resulted in less adverse events (cardiac events, multi-organ dysfunction and 30-day mortality) compared with a trigger of <100 g/L and maintaining the haemoglobin between 100 and 120 g/L.[146]

A meta-analysis of 10 randomised controlled trials comparing liberal transfusion thresholds versus restrictive found no benefit from a liberal transfusion policy. To the contrary, restrictive transfusion was associated with less blood transfused, a marginally significant reduction in cardiac events (24% lower; relative risk [RR] 0.76; 95% CI 0.57-1.0; P=0.048) and a non-significant reduction in mortality (20% lower; RR 0.80; 95% CI 0.63-1.02; P=0.07).[147]

In a multi-centre randomised controlled trial of 260 patients (without preoperative evidence of ischaemic heart disease) undergoing hip and knee replacement surgery, Grover et al[148] used Holter monitoring to compare the effects of a restrictive versus a liberal transfusion trigger (<80g/L vs <100 g/L) on incidence of silent myocardial ischaemia (SMI). They found no significant difference in incidence of SMI (restrictive 19% vs liberal 24%; P=0.41) between groups. In patients who did experience SMI, the ischaemic load was greater in the liberal compared with the restrictive group (1.51 min/h vs 0.48 min/h; ratio 0.32, 95% CI 0.14–0.76; P=0.011).

In a randomised controlled trial examining the effects of a restrictive (<80 g/L) versus a liberal (<100 g/L) transfusion threshold on post-operative ambulation in 120 patients undergoing repair of hip fracture, Foss et al[149] found no decreased function in the restrictive group. There was an increase though, in two of their secondary outcome measures, namely cardiovascular complications and 30-day mortality, in the restrictive group. However, the authors noted that their randomisation did not result in two equal groups as there were significantly more patients in the restrictive group with ASA score 3 and thus they referred to the need for larger randomised controlled trials to evaluate this outcome.

In 2009 Carson presented at the American Heart Association 2009 Scientific Sessions[1] and the AABB Annual Meeting[2] findings from a randomised controlled trial comparing a liberal (Hb<100 g/L) versus a restrictive (symptoms or Hb ≤80 g/L) transfusion policy in 2016 elderly high-cardiovascular-risk patients undergoing surgery for hip-fracture repair.[3] The mean haemoglobin at which the restrictive group was transfused was 79 g/L. The trial found no benefit from a liberal transfusion threshold in this group of high-risk patients. The restrictive group received about one-third less blood and there were no significant differences in the secondary trial outcomes, namely in-hospital rates of myocardial infarction, death, cardiac death, or a composite of myocardial infarction, unstable angina, or death.

The NHMRC 2001 Clinical Practice Guidelines recommend that, when the decision is made to transfuse, "blood should be transfused one unit at a time, followed by an assessment of benefit and further need." This recommendation is consistent with

[1] HeartWire http://www.theheart.org/article/1024017.do#bib_1 (accessed 09/01/10)

[2] AABB Annual Meeting News http://www.aabb.org/Content/Meetings_and_Events/Annual_Meeting_and_TXPO/62amonline/clintrials.htm (accessed 09/01/10)

[3] Carson et al. Transfusion Trigger Trial for Functional Outcomes in Cardiovascular Patients Undergoing Surgical Hip Fracture Repair (FOCUS)

data from a large number of recent studies demonstrating that the adverse outcomes associated with transfusion are dose-dependent, with the risk increasing with each unit given.[39, 50, 150-178]

An inappropriate and unnecessary unit transfused confers nothing but potential risk to the patient and cost to the system – without benefit.

Optimise erythropoiesis

Anaemia secondary to significant blood loss may require iron therapy to replace lost iron and reconstitute haemoglobin.

Even if patients are transfused RBCs due to haemodynamic instability and/or symptomatic severe anaemia not responding to adequate volume replacement, they may still require subsequent iron replacement therapy.[179]

Oral iron is poorly absorbed post-operatively due to the inflammatory response to surgery. In four randomised controlled trials in orthopaedic surgery, post-operative administration of oral iron failed to increase haemoglobin levels.[180-183]

A recent consensus statement on perioperative anaemia management suggested that, after operation, 150 mg of IV iron per 10 g/L fall of haemoglobin could be administered to compensate for iron loss due to perioperative bleeding.[78]

Summary

In practice, PBM is an organised team approach utilising combinations of selected patient-specific strategies in the perioperative period. Each strategy can limit blood loss and transfusion exposure (See Table 4). However, they are usually most effective when used in combinations as part of an overall peri-surgical blood conservation plan. Clinicians need to be aware of the indications, contraindications, risks and benefits of each modality, as well as the pharmacological and physiological implications of combined manoeuvres.

Table 2. Iron levels that assist in distinguishing between iron deficiency anaemia and anaemia of inflammation

	IDA*	AI*	AI+ID*
Serum iron	↓	↓	↓
Transferrin	↑	↓ to normal	↓
Transferrin saturation	↓	↓	↓
Serum ferritin	↓	Normal to ↑	↓ to normal
Soluble transferrin receptor	↑	Normal	Normal to ↑
Soluble transferrin receptor/ferritin index	High (>2)	Low (<1)	High (>2)
Hepcidin	↓	↑	↓
CRP	Normal	↑	↑

Note: Caution is needed in using ferritin levels alone as an indicator of iron stores. As ferritin is an acute-phase reactant, levels may be raised independently of iron stores in acute or chronic inflammation, infection, liver disease, hyperthyroidism, malignancies, alcohol consumption, thalassaemia, haemochromatosis and oral contraceptives. In the presence of inflammation, iron stores may be empty despite high serum ferritin levels.

Abbreviations: ↑ = increased; ↓ = decreased (*Relative changes are in relation to the respective normal values); **IDA** = Iron deficiency anaemia; **AI** = Anaemia of inflammation (also known as anaemia of chronic disease). **AI+ID** = patients with both AI and iron deficiency.

Table 3. Iron Physiology in Brief

- Iron is an essential element for the growth of all cells and the maintenance of health, while cellular iron overload leads to toxicity and cell damage
- Iron balance is regulated primarily by intestinal absorption with no regulated excretion
- Total body iron content ranges from about 2-4 g (an average of 40 mg/kg in women and 50 mg/kg in men)
  - 60-65% of body iron is in haemoglobin within the erythrocytes (~2000 mg); the remainder is in myoglobin (~175 mg), the storage compartment (ferritin [~600 mg] and haemosiderin [~200 mg]), tissue (haem and non-haem) enzymes (~125 mg), and a small percentage (<0.2%) in the transport compartment bound to transferrin (~3 mg). Iron in the transport compartment is thought to turn over every few hours
  - Approximately 20 mg of iron is recycled per day from senescent erythrocytes
  - 1-2 mg of iron is absorbed per day through the gut, representing only 10% of the average daily dietary iron intake
    - Absorption can be increased 3- to 5–fold in states of depletion in otherwise healthy patients
    - Numerous factors can enhance (eg. the amount of iron and its chemical form) or inhibit (eg. medications such as antacids, H_2 blockers, proton pump inhibitors and anti-inflammatory drugs, inflammation, and GI disease including H Pylori) iron absorption
  - 1-2 mg of iron is excreted per day by sloughing of cells of the GI tract and the skin
  - An average 60-kg female may lose an additional 10 mg/day during normal menstruation; more if there is dysfunctional uterine bleeding
  - Pregnancy uses about 700 mg of iron
- Hepcidin, a hormone produced primarily in hepatocytes, is the principal regulator of iron homeostasis. Its synthesis is inhibited by iron deficiency and stimulated in various inflammatory states
  - Decreased levels of hepcidin in iron deficiency anaemia result in increased absorption via the gastrointestinal tract and increased release of iron from the storage compartment
  - Increased levels of hepcidin, as occurs with infection, inflammation or critical illness, result in blockage of intestinal iron absorption and sequestration of iron into the storage compartment resulting in iron restricted erythropoiesis
- Iron deficiency and subsequent iron deficiency anaemia commonly develops as a result of an imbalance in iron intake, iron absorption or transport and iron loss (1mL of blood contains approximately 0.5 mg of iron)
- The anaemia of inflammation (a consequence of acute and chronic inflammatory disease including infectious and non-infectious inflammatory disorders, cancer and post-traumatic and post-surgical inflammatory states) develops as a result of cytokine-mediated dysregulation of iron homeostasis, including impaired intestinal absorption, increased uptake and retention of iron in storage, decreased erythrocyte life span, impaired erythroid progenitor cell proliferation and differentiation, and decreased production and activity of erythropoietin. Iron-restricted erythropoiesis and anaemia results, independent of depleted, normal or increased iron stores. Erythroid precursors respond rapidly to iron-transferrin, especially with IV iron administration as it appears to bypass the hepcidin blockage
- Anaemia of inflammation can coexist with and contribute to iron deficiency

Table 4. Approximate contributions of selected PBM modalities in the surgical patient	Number of RBC units saved
Perioperative	
Harnessing patient's tolerance of anaemia (restrictive transfusion trigger)	1-2[146]
Restricted phlebotomy	1[128]
Pre-operative	
Optimisation of RBC mass (perioperative anaemia management)	2[184, 185]
Intra-operative	
Meticulous haemostasis & surgical technique	1 or more[186]
Acute normovolaemic haemodilution (ANH)	1 or more[89, 187]
Autologous cell salvage	1or more[188]
Post-operative	
Autologous blood salvage	1[189]

Adapted with author consent from Shander A. Surgery without blood. Crit Care Med 2003 Dec;31(12 Suppl):S708-S714.

References:

1. Thomson A, Farmer S, Hofmann A, Isbister J, Shander A. Patient Blood Management - a new paradigm for transfusion medicine? ISBT Science Series 2009;4:423-35.
2. Martyn V, Farmer SL, Wren MN, et al. The theory and practice of bloodless surgery. Transfus Apher Sci 2002;27:29-43.
3. Goodnough LT, Shander A. Blood management. Arch Pathol Lab Med 2007;131:695-701.
4. Shander A. Surgery without blood. Crit Care Med 2003;31:S708-14.
5. Gombotz H, Rehak PH, Shander A, Hofmann A. Blood use in elective surgery: the Austrian benchmark study. Transfusion 2007;47:1468-80.
6. Baele P, Van der Linden P. Developing a blood conservation strategy in the surgical setting. Acta Anaesthesiol Belg 2002;53:129-36.
7. Cobain TJ, Vamvakas EC, Wells A, Titlestad K. A survey of the demographics of blood use. Transfus Med 2007;17:1-12.
8. WA Tomorrow - Population projections for planning regions 2004 to 2031 and local government areas 2004 to 2031. In: Government of Western Australia http://www.planning.wa.gov.au/Publications/723.aspx.
9. Hofmann A, Farmer S, Shander A. Cost-effectiveness in haemotherapies and transfusion medicine. ISBT Science Series 2009;4:423-35.
10. Kamper-Jorgensen M, Hjalgrim H, Edgren G, et al. Expensive blood safety initiatives may offer less benefit than we think. Transfusion 2009.
11. Shander A, Hofmann A, Ozawa S, Theusinger OM, Gombotz H, Spahn DR. COBCON Report of Activity Based Costs of Blood Transfusions in Surgical Patients at Four Hospitals. Transfusion 2009 in Press.
12. Shander A, Hofmann A, Gombotz H, Theusinger OM, Spahn DR. Estimating the cost of blood: past, present, and future directions. Best Pract Res Clin Anaesthesiol 2007;21:271-89.
13. Shehata N, Wilson K, Mazer CD, et al. The proportion of variation in perioperative transfusion decisions in Canada attributable to the hospital: [La proportion de variation dans les pratiques transfusionnelles perioperatoires au Canada imputable aux hopitaux]. Can J Anaesth 2007;54:902-7.
14. NHMRC/ASBT. Clinical Practice Guidelines on the Use of Blood and Blood Components In: Commonwealth of Australia; 2001.
15. Towards Better, Safer Blood Transfusion: A report for the Australian Council for safety and quality in health care. In; 2005 http://www.cec.health.nsw.gov.au/pdf/bloodwatch/better-safer-transfusion.pdf.

16. Grey DE, Smith V, Villanueva G, Richards B, Augustson B, Erber WN. The utility of an automated electronic system to monitor and audit transfusion practice. Vox Sang 2006;90:316-24.

17. Daly DJ, Myles PS, Smith JA, et al. Anticoagulation, bleeding and blood transfusion practices in Australasian cardiac surgical practice. Anaesth Intensive Care 2007;35:760-8.

18. Stramer SL, Hollinger FB, Katz LM, et al. Emerging infectious disease agents and their potential threat to transfusion safety. Transfusion 2009;49 Suppl 2:1S-29S.

19. Serious Hazards of Transfusion (SHOT) Report. In: UK Blood Service; 2008 http://www.shotuk.org/home.htm

20. Rawn J. The silent risks of blood transfusion. Curr Opin Anaesthesiol 2008;21:664-8.

21. Marik PE, Corwin HL. Efficacy of red blood cell transfusion in the critically ill: A systematic review of the literature. Crit Care Med 2008.

22. Shander A, Spence RK, Adams D, Shore-Lesserson L, Walawander CA. Timing and incidence of postoperative infections associated with blood transfusion: analysis of 1,489 orthopedic and cardiac surgery patients. Surg Infect (Larchmt) 2009;10:277-83.

23. Engoren M, Mitchell E, Perring P, Sferra J. The effect of erythrocyte blood transfusions on survival after surgery for hip fracture. J Trauma 2008;65:1411-5.

24. Spiess BD. Red cell transfusions and guidelines: a work in progress. Hematol Oncol Clin North Am 2007;21:185-200.

25. Vincent JL, Sakr Y, De Backer D, Van der Linden P. Efficacy of allogeneic red blood cell transfusions. Best Pract Res Clin Anaesthesiol 2007;21:209-19.

26. Clark CR. Perioperative blood management in total hip arthroplasty. Instr Course Lect 2009;58:167-72.

27. Munoz M, Breymann C, Garcia-Erce JA, Gomez-Ramirez S, Comin J, Disbet. Efficacy and safety of intravenous iron therapy as an alternative/adjunct to allogeneic blood transfusion. Vox Sang 2008;94:172-83.

28. Stulberg BN, Zadzilka JD. Blood management issues using blood management strategies. J Arthroplasty 2007;22:95-8.

29. Moonen AF, Neal TD, Pilot P. Peri-operative blood management in elective orthopaedic surgery. A critical review of the literature. Injury 2006;37 Suppl 5:S11-

30. Wong CJ, Vandervoort MK, Vandervoort SL, et al. A cluster-randomized controlled trial of a blood conservation algorithm in patients undergoing total hip joint arthroplasty. Transfusion 2007;47:832-41.

31. Spahn DR, Casutt M. Eliminating blood transfusions: new aspects and perspectives. Anesthesiology 2000;93:242-55.

32. Seeber P. Basics of Blood Management. In: Blackwell Publishing; 2008.

33. Spiess BD, Spence R, Shander A, eds. Perioperative Transfusion Medicine. Philadelphia: Lippincott Williams & Wilkins; 2006.

34. Pierson JL, Hannon TJ, Earles DR. A blood-conservation algorithm to reduce blood transfusions after total hip and knee arthroplasty. J Bone Joint Surg Am 2004;86-A:1512-8.

35. Martinez V, Monsaingeon-Lion A, Cherif K, Judet T, Chauvin M, Fletcher D. Transfusion strategy for primary knee and hip arthroplasty: impact of an algorithm to lower transfusion rates and hospital costs. Br J Anaesth 2007;99:794-800.

36. Slappendel R, Dirksen R, Weber EW, van der Schaaf DB. An algorithm to reduce allogenic red blood cell transfusions for major orthopedic surgery. Acta Orthop Scand 2003;74:569-75.

37. Nelson CL, Fontenot HJ, Flahiff C, Stewart J. An algorithm to optimize perioperative blood management in surgery. Clin Orthop Relat Res 1998:36-42.

38. Mercuriali F, Inghilleri G. Proposal of an algorithm to help the choice of the best transfusion strategy. Curr Med Res Opin 1996;13:465-78.

39. Beattie WS, Karkouti K, Wijeysundera DN, Tait G. Risk associated with preoperative anemia in noncardiac surgery: a single-center cohort study. Anesthesiology 2009;110:574-81.

40. Myers E, O'Grady P, Dolan AM. The influence of preclinical anaemia on outcome following total hip replacement. Arch Orthop Trauma Surg 2004;124:699-701.

41. Wu WC, Schifftner TL, Henderson WG, et al. Preoperative hematocrit levels and postoperative outcomes in older patients undergoing noncardiac surgery. JAMA 2007;297:2481-8.

42. Nissenson AR, Wade S, Goodnough T, Knight K, Dubois RW. Economic burden of anemia in an insured population. J Manag Care Pharm 2005;11:565-74.

43. Gruson KI, Aharonoff GB, Egol KA, Zuckerman JD, Koval KJ. The relationship between admission hemoglobin level and outcome after hip fracture. J Orthop Trauma 2002;16:39-44.

44. Lawrence VA, Silverstein JH, Cornell JE, Pederson T, Noveck H, Carson JL. Higher Hb level is associated with better early functional recovery after hip fracture repair. Transfusion 2003;43:1717-22.

45. Halm EA, Wang JJ, Boockvar K, et al. The effect of perioperative anemia on clinical and functional outcomes in patients with hip fracture. J Orthop Trauma 2004;18:369-74.

46. Conlon NP, Bale EP, Herbison GP, McCarroll M. Postoperative anemia and quality of life after primary hip arthroplasty in patients over 65 years old. Anesth Analg 2008;106:1056-61, table of contents.

47. Khanna MP, Hebert PC, Fergusson DA. Review of the clinical practice literature on patient characteristics associated with perioperative allogeneic red blood cell transfusion. Transfus Med Rev 2003;17:110-9.

48. Shander A, Knight K, Thurer R, Adamson J, Spence R. Prevalence and outcomes of anemia in surgery: a systematic review of the literature. Am J Med 2004;116 Suppl 7A:58S-69S.

49. Feagan BG, Wong CJ, Lau CY, Wheeler SL, Sue AQG, Kirkley A. Transfusion practice in elective orthopaedic surgery. Transfus Med 2001;11:87-95.

50. Dunne JR, Malone D, Tracy JK, Gannon C, Napolitano LM. Perioperative anemia: an independent risk factor for infection, mortality, and resource utilization in surgery. J Surg Res 2002;102:237-44.

51. Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC. Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood 2004;104:2263-8.

52. Andrews CM, Lane DW, Bradley JG. Iron pre-load for major joint replacement. Transfus Med 1997;7:281-6.

53. Munoz M, Garcia-Erce JA, Cuenca J, Bisbe E. Pharmacological management of perioperative anaemia: our experience with intravenous iron in orthopaedic surgery. ISBT Science Series 2007;2:257-63.

54. Clarke R, Grimley Evans J, Schneede J, et al. Vitamin B12 and folate deficiency in later life. Age Ageing 2004;33:34-41.

55. Bisbe E, Castillo J, Saez M, Santiveri X, Ruiz A, Munoz M. Prevalence of preoperative anemia and hematinic deficiences in patients scheduled for elective major orthopedic surgery. Transfusion Alternatives in Transfusion Medicine 2009;10:166-73.

56. Goodnough LT, Shander A, Spivak JL, et al. Detection, evaluation, and management of anemia in the elective surgical patient. Anesth Analg 2005;101:1858-61.

57. Isbister J. Investigating and treating anaemia. Current Therapeutics 2000;October:39-48.

58. Munoz M, Villar I, Garcia-Erce JA. An update on iron physiology. World J Gastroenterol 2009;15:4617-26.

59. Ganz T, Nemeth E. Iron sequestration and anemia of inflammation. Semin Hematol 2009;46:387-93.

60. Agarwal N, Prchal JT. Anemia of chronic disease (anemia of inflammation). Acta Haematol 2009;122:103-8.

61. Cuenca J, Garcia-Erce JA, Martinez F, Cardona R, Perez-Serrano L, Munoz M. Preoperative haematinics and transfusion protocol reduce the need for transfusion after total knee replacement. Int J Surg 2007;5:89-94.

62. Cuenca J, Garcia-Erce JA, Martinez F, Perez-Serrano L, Herrera A, Munoz M. Perioperative intravenous iron, with or without erythropoietin, plus restrictive transfusion protocol reduce the need for allogeneic blood after knee replacement surgery. Transfusion 2006;46:1112-9.

63. Theusinger OM, Leyvraz PF, Schanz U, Seifert B, Spahn DR. Treatment of iron deficiency anemia in orthopedic surgery with intravenous iron: efficacy and limits: a prospective study. Anesthesiology 2007;107:929-34.

64. Auerbach M, Goodnough LT, Picard D, Maniatis A. The role of intravenous iron in anemia management and transfusion avoidance. Transfusion 2008.

65. Gavi I, Auerbach M, Bailie GR, et al. Iron and the anaemia of chronic disease: a review and strategic recommendations. Curr Med Res Opin 2006;22:731-7.

66. Cuenca J, Garcia-Erce JA, Munoz M. Efficacy of intravenous iron sucrose administration for correcting preoperative anemia in patients scheduled for major orthopedic surgery. Anesthesiology 2008;109:151-2; author reply 2.

67. Garcia-Erce JA, Cuenca J, Martinez F, Cardona R, Perez-Serrano L, Munoz M. Perioperative intravenous iron preserves iron stores and may hasten the recovery from post-operative anaemia after knee replacement surgery. Transfus Med 2006;16:335-41.

68. Goodnough LT. Erythropoietin and iron-restricted erythropoiesis. Exp Hematol 2007;35:167-72.

69. Peebles G, Fenwick S. Intravenous iron administration in a short-stay hospital setting. Nurs Stand 2008;22:35-41.

70. Shortt J, Cole-Sinclair MF, Borosak M, Wood EM. Blood transfusions for iron deficiency anaemia: definitely time for a rethink! Intern Med J 2007;37:283.

71. Tampi R. Iron deficiency and iron repletion in the general population. Intern Med J 2007;37:284.

72. Shander A, Spence RK, Auerbach M. Can intravenous iron therapy meet the unmet needs created by the new restrictions on erythropoietic stimulating agents? Transfusion 2009.

73. Goodnough LT. The new age of iron: evaluation and management of iron-restricted erythropoiesis. Semin Hematol 2009;46:325-7.

74. Worwood M. Serum ferritin. CRC Crit Rev Clin Lab Sci 1979;10:171-204.

75. Finch CA, Bellotti V, Stray S, et al. Plasma ferritin determination as a diagnostic tool. West J Med 1986;145:657-63.

76. Cook JD. Diagnosis and management of iron-deficiency anaemia. Best Pract Res Clin Haematol 2005;18:319-32.

77. Guyatt GH, Patterson C, Ali M, et al. Diagnosis of iron-deficiency anemia in the elderly. Am J Med 1990;88:205-9.

78. Beris P, Munoz M, Garcia-Erce JA, Thomas D, Maniatis A, Van der Linden P. Perioperative anaemia management: consensus statement on the role of intravenous iron. Br J Anaesth 2008;100:599-604.

79. Practice guidelines for perioperative blood transfusion and adjuvant therapies: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Blood Transfusion and Adjuvant Therapies. Anesthesiology 2006;105:198-208.

80. Ang-Lee MK, Moss J, Yuan CS. Herbal medicines and perioperative care. JAMA 2001;286:208-216.

81. Johansson T, Pettersson LG, Lisander B. Tranexamic acid in total hip arthroplasty saves blood and money: a randomized, double-blind study in 100 patients. Acta Orthop 2005;76:314-9.

82. Cid J, Lozano M. Tranexamic acid reduces allogeneic red cell transfusions in patients undergoing total knee arthroplasty: results of a meta-analysis of randomized controlled trials. Transfusion 2005;45:1302-7.

83. Zufferey P, Merquiol F, Laporte S, et al. Do antifibrinolytics reduce allogeneic blood transfusion in orthopedic surgery? Anesthesiology 2006;105:1034-46.

84. Lozano M, Basora M, Peidro L, et al. Effectiveness and safety of tranexamic acid administration during total knee arthroplasty. Vox Sang 2008;95:39-44.

85. Boulton FE, James V. Guidelines for policies on alternatives to allogeneic blood transfusion. 1. Predeposit autologous blood donation and transfusion. Transfus Med 2007;17:354-65.

86. Keating EM, Ritter MA. Perioperative blood salvage as an alternative to predonating blood for primary total knee and hip arthroplasty. J Arthroplasty 2002;17:1079-80; author reply 80.

87. Goodnough LT, Despotis GJ, Merkel K, Monk TG. A randomized trial comparing acute normovolemic hemodilution and preoperative autologous blood donation in total hip arthroplasty. Transfusion 2000;40:1054-7.

88. Monk TG, Goodnough LT, Brecher ME, et al. Acute normovolemic hemodilution can replace preoperative autologous blood donation as a standard of care for autologous blood procurement in radical prostatectomy. Anesth Analg 1997;85:953-8.

89. Goodnough LT, Monk TG, Brecher ME. Acute normovolemic hemodilution should replace the preoperative donation of autologous blood as a method of autologous-blood procurement. Transfusion 1998;38:473-6.

90. Consent to Treatment Policy for the Western Australian Health System. In: Department of Health; May 2009 http://www.health.wa.gov.au/circularsnew/attachments/404.pdf.

91. Modig J, Borgeat anaesthesia and blood loss. Acta Anaesthesiol Scand Suppl 1988;89:44-8.

92. Modig J, Karlstrom G. Intra- and post-operative blood loss and haemodynamics in total hip replacement when performed under lumbar epidural versus general anaesthesia. Eur J Anaesthesiol 1987;4:345-55.

93. Rahman JM, Rowlingson AJ, Maine DN, Courpas GE, Weller JF, Wu CL. Does neuraxial anesthesia reduce intraoperative blood loss? A meta-analysis. J Clin Anesth 2006;18:427-35.

94. Kashiq S, Finegan BA. The effect of spinal anesthesia on blood transfusion rate in total joint arthroplasty. Can J Surg 2006;49:391-6.

95. Shander A, Rijhwani T. Anesthesia Techniques in Blood Conservation. In: Speiss B, Spence R, Shander A, eds. Perioperative Transfusion Medicine. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 2006:435-50.

96. Napier JA, Bruce M, Chapman J, et al. Guidelines for autologous transfusion. II. Perioperative haemodilution and cell salvage. British Committee for Standards in Haematology Blood Transfusion Task Force. Autologous Transfusion Working Party. Br J Anaesth 1997;78:768-71.

97. Bryson GL, Laupacis A, Wells GA. Does acute normovolemic hemodilution reduce perioperative allogeneic transfusion? A meta-analysis. The International Study of Perioperative Transfusion. Anesth Analg 1998;86:9-15.

98. Matot I, Scheinin O, Jurim O, Eid A. Effectiveness of acute normovolemic hemodilution to minimize allogeneic blood transfusion in major liver resections. Anesthesiology 2002;97:794-800.

99. Goodnough LT, Shander A, Spence R. Bloodless medicine: clinical care without allogeneic blood transfusion. Transfusion 2003;43:668-76.

100. Monk TG. Acute normovolemic hemodilution. Surg Infect (Larchmt) 2005;6 Suppl 1:S9-15.

101. Segal JB, Blasco-Colmenares E, Norris EJ, Guallar E. Preoperative acute normovolemic hemodilution: a meta-analysis. Transfusion 2004;44:632-44.

102. Shander A, Perelman S. The long and winding road of acute normovolemic hemodilution. Transfusion 2006;46:1075-9.

103. Bennett J, Haynes S, Torella F, Grainger H, McCollum C. Acute normovolemic hemodilution in moderate blood loss surgery: a randomized controlled trial. Transfusion 2006;46:1097-103.

104. Waters JR, Meier HH, Waters JH. An economic analysis of costs associated with development of a cell salvage program. Anesth Analg 2007;104:869-75.

105. Bridgens JP, Evans CR, Dobson PM, Hamer AJ. Intraoperative red blood-cell salvage in revision hip surgery. A case-matched study. J Bone Joint Surg Am 2007;89:270-5.

106. Waters JH, Williams B, Yazer MH, Kameneva MV. Modification of suction-induced hemolysis during cell salvage. Anesth Analg 2007;104:684-7.

107. Waters J. Blood Management: Options for Better Patient Care. In: AABB Press; 2008.

108. Haynes SL, Bennett JR, Torella F, McCollum CN. Does washing swabs increase the efficiency of red cell recovery by cell salvage in aortic surgery? Vox Sang 2005;88:244-8.

109. Waters JH, Lee JS, Karafa MT. A mathematical model of cell salvage compared and combined with normovolemic hemodilution. Transfusion 2004;44:1412-6.

110. Potter PS. Perioperative apheresis. Transfusion 2004;44:54S-7S.

111. Spotnitz WD, Burks S. Hemostats, sealants, and adhesives: components of the surgical toolbox. Transfusion 2008;48:1502-16.

112. Levy O, Martinowitz U, Oran A, Tauber C, Horoszowski H. The use of fibrin tissue adhesive to reduce blood loss and the need for blood transfusion after total knee arthroplasty. A prospective, randomized, multicenter study. J Bone Joint Surg Am 1999;81:1580-8.

113. Wang GJ, Hungerford DS, Savory CG, et al. Use of fibrin sealant to reduce bloody drainage and hemoglobin loss after total knee arthroplasty: a brief note on a randomized prospective trial. J Bone Joint Surg Am 2001;83-A:1503-5.

114. Everts PA, Devilee RJ, Brown Mahoney C, et al. Platelet gel and fibrin sealant reduce allogeneic blood transfusions in total knee arthroplasty. Acta Anaesthesiol Scand 2006;50:593-9.

115. Molloy DO, Archbold HA, Ogonda L, McConway J, Wilson RK, Beverland DE. Comparison of topical fibrin spray and tranexamic acid on blood loss after total knee replacement: a prospective, randomised controlled trial. J Bone Joint Surg Br 2007;89:306-9.

116. Wang GJ, Goldthwaite CA, Jr., Burks S, Crawford R, Spotnitz WD. Fibrin sealant reduces perioperative blood loss in total hip replacement. J Long Term Eff Med Implants 2003;13:399-411.

117. Lassen MR, Solgaard S, Kjærsgaard AG, et al. A pilot study of the effects of Vivostat patient-derived fibrin sealant in reducing blood loss in primary hip arthroplasty. Clin Appl Thromb Hemost 2006;12:352-7.

118. Mawatari M, Higo T, Tsutsumi Y, Shigematsu M, Hotokebuchi T. Effectiveness of autologous fibrin tissue adhesive in reducing postoperative blood loss during total hip arthroplasty: a prospective randomised study of 100 cases. J Orthop Surg (Hong Kong) 2006;14:117-21.

119. Bock M, Müller J, Bach A, Bohrer H, Martin E, Motsch J. Effects of preinduction and intraoperative warming during major laparotomy. Br J Anaesth 1998;80:159-63.

120. Harper CM, McNicholas T, Gowrie-Mohan S. Maintaining perioperative normothermia. BMJ 2003;326:721-2.

121. Schmied H, Schiferer A, Sessler DI, Meznik C. The effects of red-cell scavenging, hemodilution, and active warming on allogenic blood requirements in patients undergoing hip or knee arthroplasty. Anesth Analg 1998;86:387-91.

122. Schmied H, Kurz A, Sessler DI, Kozek S, Reiter A. Mild hypothermia increases blood loss and transfusion requirements during total hip arthroplasty. Lancet 1996;347:289-92.

123. Rajagopalan S, Mascha E, Na J, Sessler DI. The effects of mild perioperative hypothermia on blood loss and transfusion requirement. Anesthesiology 2008;108:71-7.

124. Sinclair S, James S, Singer M. Intraoperative intravascular volume optimisation and length of hospital stay after repair of proximal femoral fracture: randomised controlled trial. BMJ 1997;315:909-12.

125. Roche AM, James MF, Bennett-Guerrero E, Mythen MG. A head-to-head comparison of the in vitro coagulation effects of saline-based and balanced electrolyte crystalloid and colloid intravenous fluids. Anesth Analg 2006;102:1274-9.

126. Corwin HL, Parsonnet KC, Gettinger A. RBC transfusion in the ICU. Is there a reason? Chest 1995;108:767-71.

127. Chant C, Wilson G, Friedrich JO. Anemia, transfusion, and phlebotomy practices in critically ill patients with prolonged ICU length of stay: a cohort study. Crit Care 2006;10:R140.

128. Smoller BR, Kruskall MS. Phlebotomy for diagnostic laboratory tests in adults. Pattern of use and effect on transfusion requirements. N Engl J Med 1986;314:1233-5.

129. Thavendiranathan P, Bagai A, Ebidia A, Detsky AS, Choudhry NK. Do blood tests cause anemia in hospitalized patients? The effect of diagnostic phlebotomy on hemoglobin and hematocrit levels. J Gen Intern Med 2005;20:520-4.

130. Smoller BR, Kruskall MS, Horowitz GL. Reducing adult phlebotomy blood loss with the use of pediatric-sized blood collection tubes. Am J Clin Pathol 1989;91:701-3.

131. Sturdee SW, Beard DJ, Nandhara G, Sonanis SV. Decreasing the blood transfusion rate in elective hip replacement surgery using an autologous drainage system. Ann R Coll Surg Engl 2007;89:136-9.

132. Mirza SB, Campion J, Dixon JH, Panesar SS. Efficacy and economics of postoperative blood salvage in patients undergoing elective total hip replacement. Ann R Coll Surg Engl 2007;89:777-84.

133. Moonen AF, Knoors NT, van Os JJ, Verburg AD, Pilot P. Retransfusion of filtered shed blood in primary total hip and knee arthroplasty: a prospective randomized clinical trial. Transfusion 2007;47:379-84.

134. Moonen AF, Thomassen BJ, van Os JJ, Verburg AD, Pilot P. Retransfusion of filtered shed blood in everyday orthopaedic practice. Transfus Med 2008;18:355-9.

135. Grosvenor D, Goyal V, Goodman S. Efficacy of postoperative blood salvage following total hip arthroplasty in patients with and without deposited autologous units. J Bone Joint Surg Am 2000;82-A:551-4.

136. Clark CR, Spratt KF, Blondin M, Craig S, Fink L. Perioperative autotransfusion in total hip and knee arthroplasty. J Arthroplasty 2006;21:23-35.

137. Dagi TF. The management of postoperative bleeding. Surg Clin North Am 2005;85:1191-213, x.

138. Zauder H. How Did We Get a "Magic Number" for Preoperative Hematocrit/Hemoglobin Level? In: Perioperative Red Cell Transfusion NIH Consensus Development Conference Proceedings; 1988; 1988.

139. Consensus conference. Perioperative red blood cell transfusion. JAMA 1988;260:2700-3.

140. Practice strategies for elective red blood cell transfusion. American College of Physicians. Ann Intern Med 1992;116:403-6.

141. Ferraris VA, Ferraris SP, Saha SP, et al. Perioperative blood transfusion and blood conservation in cardiac surgery: the Society of Thoracic Surgeons and The Society of Cardiovascular Anesthesiologists clinical practice guideline. Ann Thorac Surg 2007;83:S27-86.

142. Fink A, Javidroozi M, Ozawa S, et al. The International Consensus Conference on Transfusion and Outcomes. Transfusion 2009;In press.

143. Rao SV, Jollis JG, Harrington RA, et al. Relationship of blood transfusion and clinical outcomes in patients with acute coronary syndromes. JAMA 2004;292:1555-62.

144. Aronson D, Dann EJ, Bortnikov V, et al. Impact of red blood cell transfusion on clinical outcomes in patients with acute myocardial infarction. Am J Cardiol 2008;102:115-9.

145. Alexander KP, Chen AY, Wang TY, et al. Transfusion practice and outcomes in non-ST-segment elevation acute coronary syndromes. Am Heart J 2008;155:1047-53.

146. Hebert PC, Wells G, Blajchman MA, et al. A multicenter, randomized, controlled clinical trial of transfusion requirements in critical care. Transfusion Requirements in Critical Care Investigators, Canadian Critical Care Trials Group. N Engl J Med 1999;340:409-17.

147. Carson JL, Hill S, Carless P, Hebert P, Henry D. Transfusion triggers: a systematic review of the literature. Transfus Med Rev 2002;16:187-99.

148. Grover M, Talwalkar S, Casbard A, et al. Silent myocardial ischaemia and haemoglobin concentration: a randomized controlled trial of transfusion strategy in lower limb arthroplasty. Vox Sang 2006;90:105-12.

149. Foss NB, Kristensen MT, Jensen PS, Palm H, Krasheninnikoff M, Kehlet H. The effects of liberal versus restrictive transfusion thresholds on ambulation after hip fracture surgery. Transfusion 2009;49:227-34.

150. Chaiwat O, Lang JD, Vavilala MS, et al. Early packed red blood cell transfusion and acute respiratory distress syndrome after trauma. Anesthesiology 2009;110:351-60.

151. Salim A, Hadjizacharia P, DuBose J, et al. Role of anemia in traumatic brain injury. J Am Coll Surg 2008;207:398-406.

152. Bochicchio GV, Napolitano L, Joshi M, Bochicchio K, Meyer W, Scalea TM. Outcome analysis of blood product transfusion in trauma patients: a prospective, risk-adjusted study. World J Surg 2008;32:2185-9.

153. Malone DL, Dunne J, Tracy JK, Putnam AT, Scalea TM, Napolitano LM. Blood transfusion, independent of shock severity, is associated with worse outcome in trauma. J Trauma 2003;54:898-905; discussion -7.

154. Croce MA, Tolley EA, Claridge JA, Fabian TC. Transfusions result in pulmonary morbidity and death after a moderate degree of injury. J Trauma 2005;59:19-23; discussion -4.

155. Zilberberg MD, Carter C, Lefebvre P, et al. Red blood cell transfusions and the risk of acute respiratory distress syndrome among the critically ill: a cohort study. Crit Care 2007;11:R63.

156. Gong MN, Thompson BT, Williams P, Pothier L, Boyce PD, Christiani DC. Clinical predictors of and mortality in acute respiratory distress syndrome: potential role of red cell transfusion. Crit Care Med 2005;33:1191-8.

157. Shorr AF, Jackson WL, Kelly KM, Fu M, Kollef MH. Transfusion practice and blood stream infections in critically ill patients. Chest 2005;127:1722-8.

158. Corwin HL, Gettinger A, Pearl RG, et al. The CRIT Study: Anemia and blood transfusion in the critically ill--current clinical practice in the United States. Crit Care Med 2004;32:39-52.

159. Taylor RW, Manganaro L, O'Brien J, Trottier SJ, Parkar N, Veremakis C. Impact of allogenic packed red blood cell transfusion on nosocomial infection rates in the critically ill patient. Crit Care Med 2002;30:2249-54.

160. Karkouti K, Wijeysundera DN, Beattie WS. Risk associated with preoperative anemia in cardiac surgery: a multicenter cohort study. Circulation 2008;117:478-84.

161. Scott BH, Seifert FC, Grimson R. Blood transfusion is associated with increased resource utilisation, morbidity and mortality in cardiac surgery. Ann Card Anaesth 2008;11:15-9.

162. Murphy GJ, Reeves BC, Rogers CA, Rizvi SI, Culliford L, Angelini GD. Increased Mortality, Postoperative Morbidity, and Cost After Red Blood Cell Transfusion in Patients Having Cardiac Surgery. Circulation 2007.

163. Kulier A, Levin J, Moser R, et al. Impact of preoperative anemia on outcome in patients undergoing coronary artery bypass graft surgery. Circulation 2007;116:471-9.

164. Banbury MK, Brizzio ME, Rajeswaran J, Lytle BW, Blackstone EH. Transfusion increases the risk of postoperative infection after cardiovascular surgery. J Am Coll Surg 2006;203:131-8.

165. Koch CG, Li L, Duncan AI, et al. Morbidity and mortality risk associated with red blood cell and blood-component transfusion in isolated coronary artery bypass grafting. Crit Care Med 2006;34:1608-16.

166. Koch CG, Li L, Duncan AI, et al. Transfusion in coronary artery bypass grafting is associated with reduced long-term survival. Ann Thorac Surg 2006;81:1650-7.

167. Koch CG, Khandwala F, Li L, Estafanous FG, Loop FD, Blackstone EH. Persistent effect of red cell transfusion on health-related quality of life after cardiac surgery. Ann Thorac Surg 2006;82:13-20.

168. Rogers MA, Blumberg N, Saint SK, Kim C, Nallamothu BK, Langa KM. Allogeneic blood transfusions explain increased mortality in women after coronary artery bypass graft surgery. Am Heart J 2006;152:1028-34.

169. Rogers MA, Blumberg N, Heal JM, Hicks GL, Jr. Increased risk of infection and mortality in women after cardiac surgery related to allogeneic blood transfusion. J Womens Health (Larchmt) 2007;16:1412-20.

170. Basran S, Frumento RJ, Cohen A, et al. The association between duration of storage of transfused red blood cells and morbidity and mortality after reoperative cardiac surgery. Anesth Analg 2006;103:15-20, table of contents.

171. Leal-Noval SR, Rincon-Ferrari MD, Garcia-Curiel A, et al. Transfusion of blood components and postoperative infection in patients undergoing cardiac surgery. Chest 2001;119:1461-8.

172. Bernard AC, Davenport DL, Chang PK, Vaughan TB, Zwischenberger JB. Intraoperative transfusion of 1 U to 2 U packed red blood cells is associated with increased 30-day mortality, surgical-site infection, pneumonia and sepsis in general surgery patients. J Am Coll Surg 2009;208:931-7, 7 e1-2; discussion 8-9.

173. Bursi F, Barbieri A, Politi L, et al. Perioperative red blood cell transfusion and outcome in stable patients after elective major vascular surgery. Eur J Vasc Endovasc Surg 2009;37:311-8.

174. Wagoditsch M, Pozgainer P, Klingler A, Tschmelitsch J. Impact of blood transfusions on recurrence and survival after rectal cancer surgery. Dis Colon Rectum 2006;49:1116-30.

175. Chang H, Hall GA, Geerts WH, Greenwood C, McLeod RS, Sher GD. Allogeneic red blood cell transfusion is an independent risk factor for the development of postoperative bacterial infection. Vox Sang 2000;78:13-8.

176. Ho C, Sucato DJ, Richards BS. Risk factors for the development of delayed infections following posterior spinal fusion and instrumentation in adolescent idiopathic scoliosis patients. Spine 2007;32:2272-7.

177. Carson JL, Altman DG, Duff A, et al. Risk of bacterial infection associated with allogeneic blood transfusion among patients undergoing hip fracture repair. Transfusion 1999;39:694-700.

178. Palmieri TL, Caruso DM, Foster KN, et al. Effect of blood transfusion on outcome after major burn injury: a multicenter study. Crit Care Med 2006;34:1602-7.

179. Ahmad I, Gibson PR. Management of iron deficiency in patients admitted to hospital: time for a rethink of treatment principles. Intern Med J 2006;36:347-54.

180. Mundy GM, Birtwistle SJ, Power RA. The effect of iron supplementation on the level of haemoglobin after lower limb arthroplasty. J Bone Joint Surg Br 2005;87:213-7.

181. Sutton PM, Cresswell T, Livesey JP, Speed K, Bagga T. Treatment of anaemia after joint replacement. A double-blind, randomised, controlled trial of ferrous sulphate versus placebo. J Bone Joint Surg Br 2004;86:31-3.

182. Weatherall M, Maling TJ. Oral iron therapy for anaemia after orthopaedic surgery: randomized clinical trial. ANZ J Surg 2004;74:1049-51.

183. Zauber NP, Zauber AG, Gordon FJ, et al. Iron supplementation after femoral head replacement for patients with normal iron stores. JAMA 1992;267:525-7.

184. Goodnough LT, Price TH, Rudnick S, Soegiarso RW. Preoperative red cell production in patients undergoing aggressive autologous blood phlebotomy with and without erythropoietin therapy. Transfusion 1992;32:441-5.

185. Goodnough LT, Skikne B, Brugnara C. Erythropoietin, iron, and erythropoiesis. Blood 2000;96:823-33.

186. Spence RK, Cernaianu AC, Carson J, DelRossi AJ. Transfusion and surgery. Curr Probl Surg 1993;30:1101-80.

187. Monk TG, Goodnough LT, Birkmeyer JD, Brecher ME, Catalona WJ. Acute normovolemic hemodilution is a cost-effective alternative to preoperative autologous blood donation by patients undergoing radical retropubic prostatectomy. Transfusion 1995;35:559-65.

188. Goodnough LT, Monk TG, Sicard G, et al. Intraoperative salvage in patients undergoing elective abdominal aortic aneurysm repair: an analysis of cost and benefit. J Vasc Surg 1996;24:213-8.

189. Goodnough LT, Brecher ME, Kanter MH, AuBuchon JP. Transfusion medicine. Second of two parts--blood conservation. N Engl J Med 1999;340:525-33.

Appendix 2. Hip and Knee Arthritis in Obese Patients

Department of Orthopaedic Surgery, Fremantle Hospital

The orthopaedic surgeon is one of many practitioners faced with the consequences of the alarming escalation in population obesity. Currently, 46% of males and 23% of females between the ages of 55-64 are obese (BMI >30). Over one third of hip and knee replacements are performed on obese patients. With respect to hip and knee osteoarthritis, obesity means that arthritis occurs more often and at an earlier age. Obese people tend to have their joint replacement much younger, on average 10-13 years earlier [1].
Weight loss has been shown to lead to a reduction in incidence of arthritis, as well as the chronic diseases associated with obesity e.g. type 2 diabetes mellitus, coronary artery disease and stroke. Weight loss should be instituted early in adult life. For example, women who are obese at age 18 have a five-fold increased risk of having a total hip replacement (THR) in later life [2]. Those who are morbidly obese have a relative risk for THR increased by 8.6 times, and a relative risk of TKR increased by 32.7 times compared with a normal weight individual [3]. In patients with symptomatic arthritis, weight loss can lead to a dramatic reduction in symptoms. Meta analysis has shown that a 5.1% reduction in weight can significantly improve disability [4]. Despite this, it is often very difficult to lose weight when mobility is impaired.

Obesity and Total Hip Replacement (THR)

The outcomes for joint replacements can be divided into two broad categories:

- early outcomes/complications;
- long-term survival.

These outcomes are largely dependent on the level of obesity. The World Health Organisation (WHO) classification (obesity BMI>30kg/m^2, morbid obesity BMI>40kg/m^2) has been largely used in the orthopaedic literature.
With regards to THRs, the majority of earlier studies show no difference in long-term survival rates at follow-up in obese and morbidly obese patients [5,6]. Furthermore, there appears to be no increased risk of infection, dislocation, or blood transfusion and no significant difference in pain, function or quality of life (QOL) scores between obese (BMI 30-40kg/m^2) suggesting that the obese patient with a THR derives just as much benefit from a THR as a non-obese patient. Even the morbidly obese (BMI >40kg/m^2) have been shown to do as well as non-obese patients [5].

More recently, it has been shown that obesity and morbid obesity are associated with a higher rate of infection, at 2.6% and 9.1%, respectively [7]. It has been suggested that other studies have not shown an increased infection rate in the obese patient, because of small population numbers, and rare complications such as infection would not manifest itself unless population numbers were large [8].

Considering the available evidence, it would seem that THRs can be safely performed on obese patients, albeit with a slightly higher infection rate. However, there appears to be a propensity to higher infection rates in patients

who are morbidly obese,.Further studies looking at the morbidly obese subgroup will help clarify the situation.

Obesity and Total Knee Replacement (TKR)

The evidence appears to be more clear-cut with regards to TKRs. Following total knee replacement, most studies comparing obese and non-obese patients show no difference in complication rates, clinical outcome scores and long-term survival, except perhaps for an increased incidence of patellofemoral symptoms in obese patients [9]. The situation is not so favourable in the morbidly obese (BMI>40kg/m^2) compared to obese and non-obese patients [10,11,12]. Those with a BMI >40kg/m^2 have a significant difference in knee function scores, complication rates (32% vs 0%), and survival (72.3% vs 97.6%) [12]. Caution should therefore be used in morbidly obese patients contemplating a total knee replacement. Other problems associated with obesity include diabetes, hypertension and premature death. Moreover, caring for obese patients raises occupational health and safety risks for staff.

Weight Loss Following Joint Replacement.

Surprisingly, patients tend to gain weight following surgery. This has been shown in two prospective studies [13,14]. The patient expectation that joint replacement surgery will improve mobility and that exercise will lead to weight loss needs to be revised, and patients counselled accordingly. Assistance to achieve ongoing weight loss should be offered from a multidisciplinary team including dietetics, physiotherapy, and medicine.

Role of Bariatric Surgery

Bariatric surgery has been shown in meta-analysis to effect weight loss, the mean percentage of excess weight loss being 61.2%. It has also been shown to resolve diabetes in 76.8% in patients, improve hyperlidaemia in 70%, resolve hypertension in 61.7% and eliminate obstructive sleep apnoea in 83.6% of patients [15].

There has been little research performed on the role of bariatric surgery in the morbidly obese prior to joint replacement surgery. The one study to date of 20 morbidly obese patients showed that bariatric surgery reduced the BMI from an average of 49 to 29kg/m^2, and the average time from bariatric surgery to arthroplasty was 23 months. There was only one revision performed at medium term follow up, and the authors felt that bariatric surgery should therefore be considered prior to arthroplasty[16].

Conclusions and Protocols For Joint Replacement Surgery in Obese Patients

- All obese (BMI>30kg/m^2) patients should be referred to physiotherapy and a dietician when waitlisted for their TKR or THR.
- All morbidly obese (BMI>40kg/m^2) patients will need to achieve a BMI <40kg/m^2 prior to being waitlisted for their TKR or THR. In conjunction with physiotherapy and dietary advice, they will be referred to an appropriate specialist, and offered gastric banding surgery to achieve a target BMI < 40kg/m^2.

References

1. Changulani M, Kalairajah Y, Peel T, Field RE. The relationship between obesity and the age at which hip and knee replacement is undertaken J. Bone Joint Surg. Br. 2008:90:360-363
2. Karlson EW, Mandl LA, Gideon N, Aweh GN, Sangha, Liang et al. Total Hip[Replacement due to osteoarthritis: the importance of age, obesity and other modifiable risk factors. Am J Med 2003;114:93-98
3. Bourne R, Mukhi S, Zhu N et al. Role of obesity on the risk of total hip or knee arthroplasty. Clin Orthop. Relat. Res. 2007;465:185-188
4. Christensen R, Bartels EM, Astrup A, Bliddal H. Effect of weight reduction in obese patients diagnosed with knee osteoarthritis: a systematic review and meta-analysis. Annals of the Rheum. Dis. 2007;66(4):433-439
5. Andrew JG, Palan J, Kurup HV, Gibson P, Murray DW, Beard DJ. Obesity in total hip replacement. J. Bone Joint Surg Br 2008;90: B: 424-429
6. McLaughlin JR, Lee KR. The outcome of total hipreplacement in obese and non-obese patients at 10-18 years. J. Bone Joint Surg. Br. 2006;88: B: 1286-1292
7. Dowsey MM, Choong PF. Obesity is a major risk factor for prosthetic infection after primary hip arthroplasty. Clin Orthop. Relat. Res. 2008;466:153-158
8. Dowsey MM, Choong PF. Early outcomes and complications following joint arthroplasty in obese patients: a review of the published reports. ANZ J. Surg. 2008;78:439-444
9. Stern SH, Insall JN. Total knee arthroplasty in obese patients. J. Bone Joint Surg Am 1990; 72;A: 1400-1404
10. Foran JRH, Mont MA, et al. The outcome of total knee arthroplasty in obese patients. J Bone Joint Surg Am. 2004; 86:A:1609-1615
11. Winiarsky R, Barth P, Lotke P. Total knee arthroplasty in morbidly obese patients. J Bone Joint Surg Am. 1998;80:A:1770-1774
12. Amin AK, Clayton RAE, PattonJT, Gaston M. Total knee replacement in morbidly obese patients: results of a prospective matched study. J Bone Joint Surg Br 2006:88: 1321-1326
13. Woodruff MJ, Stone MH. Comparison of weight changes after total hip or knee arthroplasty. Journal of arthroplasty. 2001; 16:22-24
14. Alterinto J, Brenkel IJ, Chan P. Weight change following total hip replacement: a comparison of obese and non-obese patients. Surgeon 2005;3:269-272
15. Buchwald H, Avidor Y, Braunwald E et al. Bariatric surgery: a systematic review and meta analysis. JAMA 2004;292:1724-1728
16. Parvizi J, Trousdale RT, Sarr MG. Total joint arthroplasty in patients surgically treated for morbid obesity. Journal of arthroplasty. 2000;15:1003-1008

Appendix 3.

Perth Bone and Tissue Bank Protocols (revised October 2012)

PERTH BONE & TISSUE BANK INC.

Protocol for femoral head donation to the Perth Bone and Tissue Bank (PBTB)

The following information has been provided by the Perth Bone and Tissue Bank (PBTB) Inc. The femoral head donation process is also summarised in Figure 1.

1. REFERRAL

Potential femoral head (FH) donors may be identified either through the hospitals' orthopaedic outpatient clinics, hospital preadmission clinics or hospital in patient bookings.

Informing patients about femoral head donation (FHD):

a) Hospital orthopaedic registrar or surgeon:
When patients are deemed appropriate candidates for primary total hip replacement and added to the surgical waiting list, the doctor should inform the patient verbally about FHD. The patient should then be provided with a Perth Bone and Tissue Bank (PBTB) information pack.

b) Preadmission clinic:
Patients should be provided with the PBTB FHD Information Package

Notifying PBTB of potential FH donors

a) Preadmission clinics fax a referral form each time a PBTB FHD Information Package is given to a patient, ***or***

b) Hospital in-patient bookings department fax the booking lists as patients are booked for primary total hip joint replacements, ***or***

c) Voluntary notification; the patient contacts PBTB themselves. Further information about the PBTB and the donation process can be viewed at the PBTB website.

2. ASSESSING POTENTIAL DONORS

It is preferable that the potential donor has the opportunity to read the information provided in the Femoral Head donation Information Pack in their own time, prior to agreeing to donate.

Where the patient has received the PBTB FHD Information Package, the patient completes **Form D2: FH Consent, Medical, and Social History** and mails it to PBTB. On receipt of the form, PBTB reviews the information with the patient over the phone, follows up any additional medical information; and records the patient's consent.

3. THEATRE NOTIFICATION OF POTENTIAL DONOR

Where PBTB assesses the patient as suitable to donate their femoral head, PBTB notifies the hospital theatre and forwards a FH collection checklist to the theatre.

4. FACE TO FACE INTERVIEW

It is a regulatory requirement that all donors are interviewed in person.

Where possible, PBTB Donor Liaison staff visit the potential donor in hospital prior to surgery, for final review and sign off of the patient's medical and social history documentation and the donation consent.

Alternatively, once the FH donation is received at PBTB, PBTB Donor Liaison staff visit the patient in hospital after surgery

In some instances, at the discretion of PBTB, hospital staff may be trained and subsequently authorised by PBTB to conduct the document review interviews.

5. WHAT CAN GO WRONG

- Pre-admission clinics or in-patient bookings department fail to notify PBTB of patients undergoing hip replacement procedures.
- Referrals are received by PBTB less than 5 working days prior to surgery – this does not allow sufficient time for the donor to complete and mail **Form D2: FH Consent, Medical, and Social History** to PBTB; review of the potential donor's medical history; and/or the patient interview to be undertaken.
- Theatres fail to collect the FH when they have been notified to do so.
- Patients are discharged before PBTB have been able to conduct an in-person interview.
- Hospital staff who have been trained and authorised by PBTB to conduct in person interviews are sought, particularly in outlying hospitals such as Peel and Joondalup.

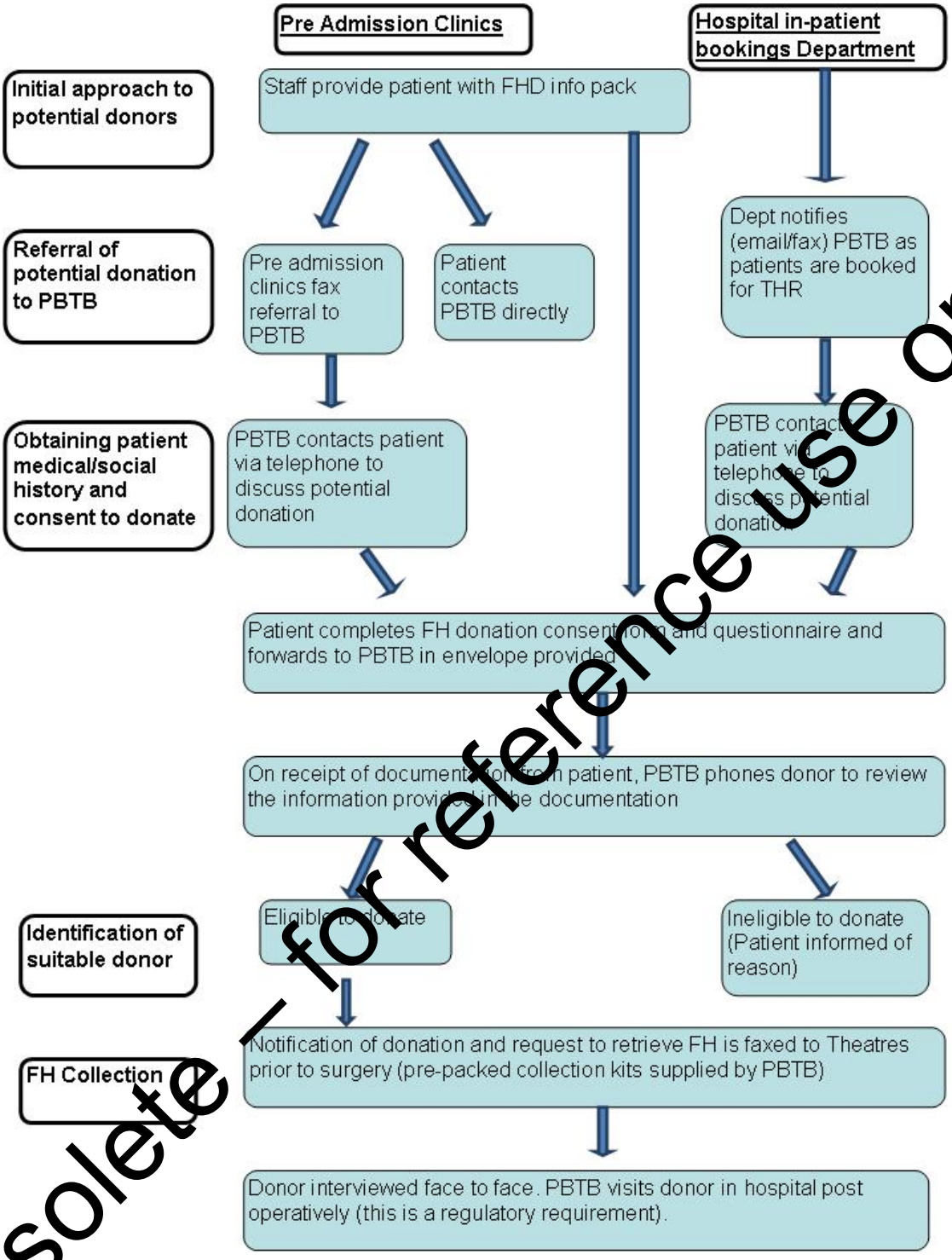


Figure 1: Femoral head donation in the public hospital system. Arrows indicate the various pathways for obtaining femoral head donations.

PERTH BONE & TISSUE BANK INC.

Process for requesting allograft

1. OBTAINING CONSENT

- Recipient's consent must be obtained **prior to** the operation and premedication
- Recipient must sign form E *Consent to Receive Allograft*
- Recipient's signature **must** be witnessed by a Medical Officer

Graft material will not be supplied before PBTB has received form E signed & witnessed except for the following exceptional circumstances:

1. The need for Allograft use could not be foreseen preoperatively (primary and revision joint surgery do not fall within this category), **and**
2. Autologous graft cannot be used, **and**
3. Consent of the next of kin is obtained, **and**
4. The Medical Director of the hospital, formally and in writing, accepts responsibility for any consequences of the use of the graft.

2. REQUESTING ALLOGRAFT MATERIAL

Telephone PBTB on (08) 9386 9300 stating:

1. Recipient's details – name, age and rhesus factor where the recipient is a female with the possibility of having a child sometime in the future
2. Surgeon.
3. Date of surgery, time and hospital
4. Type and amount of graft required

OR

Complete Form E ***Consent to Receive Allograft*** and mail or fax it to

Perth Bone & Tissue Bank Inc

PO Box 1735

Nedlands WA 6909

Fax (08) 9386 9344

When requesting allograft from country areas, the requesting surgeon should send specific size requirements to enable suitable graft to be allocated OR send the patient's X-rays to compare with the allograft X-ray.

Delivering a **Healthy WA**

Health Networks Branch
Department of Health
Level 2C, 189 Royal Street
East Perth
Western Australia 6004