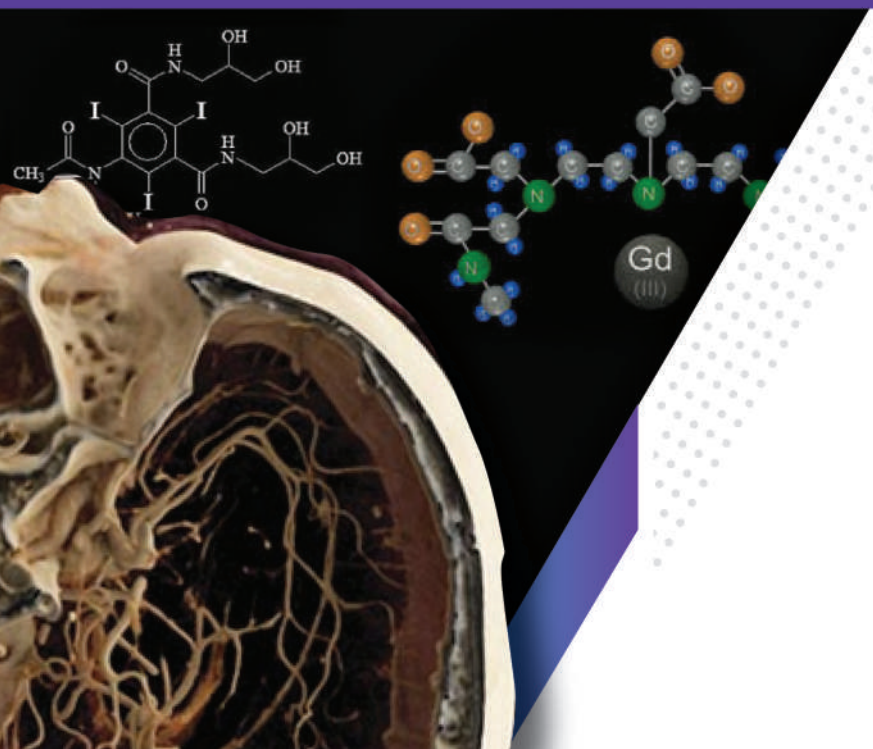
MOH/P/PAK/518.23(GU)

CLINICAL SUPPORT SERVICES UNIT
MEDICAL DEVELOPMENT DIVISION, MOH

NATIONAL RADIOLOGY

INTRAVASCULAR CONTRAST MEDIA

STANDARD OPERATING PROCEDURE (SOP)



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A catalogue record for this book is available from the Library and Resource Unit of the Institute of Medical Research, Ministry of Health;

MOH/P/PAK/518.23(GU)

Also available From the National Library of Malaysia;

ISBN 978-967-26348-3-6

9 789672 634836

Published in January 2024

This policy was developed by the Medical Development Division and the Drafting Committee of the National Radiology Intravascular Contrast Media Standard Operating Procedures (SOP).

CONTENTS

Disclaimer:
The information provided in this document is a general guideline only and not intended as a substitute for medical or legal advice. This document is not a stand-alone document. It is designed to support and not replace the relationship that exists between a patient and his/her doctor. (Adapted from [22])

FOREWORD

DIRECTOR-GENERAL OF HEALTH, MALAYSIA

Current medical practice relies heavily on medical imaging, which utilises contrast media to assist in patient management including the clinical diagnosis and treatment. Therefore, it is imperative that all stakeholders involved in the provision medical imaging services have a clear understanding of the use of intravascular contrast media.

The National Radiology Intravascular Contrast Media Standard Operating Procedure (SOP) is intended to guide radiologist, clinicians, and other healthcare professionals in administering iodinated and gadolinium-based contrast media to patients undergoing medical imaging procedures. It is expected to provide healthcare professionals with updated guidance and appropriate point-of-care tools to be used by clinical practitioners to facilitate the recommended implementation.

The publication of this standard operating procedure is timely, and it is aimed at setting out the principles and arrangements for high quality patient care. It is hoped that this document will assist and guide radiology and non-radiology personnel on safe practice in contrast media administration and to prevent any adverse events.

Finally, I would like to congratulate the Medical Development Division and the National Radiology Services for their tremendous dedication and commitment for successfully producing this document. Henceforth, I believe that this commitment will continue safeguarding Ministry Of Health's mission to provide patients with safe, effective and good clinical practice.

Datuk Dr. Muhammad Radzi bin Abu Hassan

FOREWORD

DEPUTY DIRECTOR-GENERAL OF HEALTH, MALAYSIA

Although the contrast agents in current use have been on the market for many years, minor changes occur in their adverse reaction pattern and new observations are reported. This National Radiology Intravascular Contrast Media Standard Operating Procedure (SOP) includes updated sections on acute adverse reactions, gadolinium contrast agents and other gadolinium issues, post contrast acute kidney injury (PC-AKI) and myeloma and contrast media.

Having such SOP is necessary because of the ever-changing literature about both iodinated contrast media and Gadolinium-based contrast agents (GBCAs) which calls for a standardisation in Ministry of Health facilities. This SOP was developed by the Ministry of Health National Radiology Services as a guide for practicing radiologists and clinicians to enhance the safe and effective use of contrast media. The committee involved in the preparation of the SOP offers this document as a consensus of scientific evidence and clinical experience concerning the use of contrast media. Suggestions for patient screening, premedication, recognition of adverse reactions, and emergency treatment of such reactions are emphasized. Its major purpose is to provide useful information regarding contrast media used in daily practice.

It is hoped that this SOP will be practiced by all those involved in the administration of contrast media to patients in all Ministry of Health facilities.

Dato' Dr. Asmayanti binti Khalib

FOREWORD

HEAD OF SPECIALTY FOR CLINICAL RADIOLOGY

Critical clinical support services such as radiology continues to play a vital collaborative role in assisting diagnoses and treatment of patient these days. Contrast media are becoming more widely used to improve medical imaging for these purposes, hence its use needs to be standardised. In line with our Director-General of Health's frequent emphasis on patient safety, this protocol has come in timely to guide radiologists and clinicians in the utilisation of intravascular contrast media.

Standards operative procedure documents are necessary to provide guidance to radiologists and other clinicians involved in the delivery of radiological services with the aim of improving the service for the benefit of patients by defining best practice, and promoting advances in practice. National Radiology Services MOH is committed to review all relevant publications in line with the recommendations of usage of intravascular contrast media following the global standard. This standard operative procedure is not a regulation governing practice but attempts to define the aspects of radiological services and care which promote the provision of a high quality service to patients.

National Radiology Services Ministry Of Health is delighted to note the efforts put in by various senior consultants, clinical specialists and support staff in publishing this important document. It is hoped that these clinical input and standard operating procedure can be replicated nationwide to promote good clinical practice that will benefit all patients.

Dr Norzaini Rose bt Mohd Zain

FOREWORD

CHAIRMAN OF DEVELOPMENT COMMITTEE

Assalamualaikum dan Salam Sejahtera,

National Radiology Intravascular Contrast Media Standard Operating Procedure (SOP) is an inspiration from an initial document of Radiology Contrast Media Manual that I prepared in readiness for 2008 accreditation of Hospital Sultan Haji Ahmad Shah (HoSHAS, Temerloh, Pahang). I volunteered to prepare the National Radiology Intravascular Contrast Media Standard Operating Procedure (SOP) where the need arose in 2019 due to an incident of intravenous contrast media extravasation known nationally resulting in medico-legal case.

Hence a development committee in which I was a chairman was formed as well as a review committee whose members are from other involved disciplines and the Head Of Specialty For Clinical Radiology. I am grateful to the Development and Review Committees for sharing this valuable knowledge.

The initial document was revamped and improved according to current best practice. The National Radiology Intravascular Contrast Media SOP was done to tailor to our current accepted local practice and resources. This document aims to provide a guideline and assist KKM radiologists on strategies, current accepted practices on safe as well as effective use of intravascular contrast media in our daily practice that will benefit all patients.

I would like to thank the Director-General of Health, YBhg. Datuk Dr. Muhammad Radzi Bin Abu Hassan and Deputy Director-General of Health (Medical), Ministry of Health Malaysia, YBhg. Dato' Dr. Asmayani binti Khalib for their support in formation of this SOP. I would also like to thank the Head Of Specialty For Clinical Radiology, YBrs. Dr. Norzaini Rose binti Mohd Zain and Precedent Head Of Specialty for Clinical Radiology, YBrs. Dr. Yun Sii Ing for their support, guidance and feedback in the formation of this document. A special appreciation to those who have dedicated their time and effort during preparation of this document including the feedback from KKM Radiology fraternity. It is my hope that this SOP will be a useful reference with regards to Radiology practice in KKM hospitals.

Thank You.

Dr. Nazrila Hairiana binti Dato' Nasir

INTRAVASCULAR CONTRAST MEDIA

STANDARD OPERATING PROCEDURE (SOP)

1. INTRODUCTION

The National Radiology Intravascular Contrast Media Standard Operating Procedure serves as a structured framework of intravascular contrast media uses and its practice in Radiology Departments.

This National Radiology Intravascular Contrast Media Standard Operating Procedure shall be updated once in 5 years or when necessary. The use of professional judgement by the radiologist and the treating physician is paramount on a case-by-case basis when a riskbenefit analysis has been made and the imaging investigation with administration of contrast is deemed medically necessary by the referring specialist and attending radiologist. Modifications may also be done according to current recommended practice. Such determination will be noted in the patient's record/ report.

2. PURPOSE : To Guide

a) Proper patient evaluation prior to contrast-enhanced examinations.
b) Appropriate actions are taken in cases requiring referral to relevant department or premedication in patients with known/suspected allergic reactions.
c) Contrast administration is performed according to standard protocol.
d) Appropriate actions are undertaken in case of contrast reactions and extravasation of contrast.
e) Proper documentation of the processes involved is observed and further justification and clarification of indication by the primary and the radiology teams.

The SOP is based on the American College of Radiology Manual on Contrast Media 2021, European Society of Urogenital Radiology (ESUR) Guidelines on Contrast Media version 10.0 and other relevant literature, adopted and adapted to local level and practices.

3. SCOPE : Safety, Appropriateness

Overview usage of contrast media at all Radiology facilities in MOH in terms of its safety, appropriateness and managing complications.

4. DEFINITIONS OF TERMS

a. **First pass** [2] - Intra-arterial injection with first pass renal exposure indicates that contrast agent reaches the renal arteries in a relatively undiluted form, e.g., injection into the left heart, thoracic and suprarenal abdominal aorta, or the renal arteries.
b. **Second pass** [2]:-
   i. Intra-arterial injection with second pass renal exposure indicates that contrast agent reaches the renal arteries after dilution either in the pulmonary or peripheral circulation, e.g., injection into the right heart, pulmonary artery, coronary, carotid, subclavian, mesenteric, or infra-renal arteries.

ii. Intravenous (IV) contrast reaches the renal arteries after passing the right heart and the pulmonary circulation and is thus diluted. This counts as the second pass renal exposure. For example, all contrast enhanced CT examinations with IV contrast injection.

c. **Contrast-associated acute kidney injury (CA-AKI)**, formerly known as post-contrast acute kidney injury (PC-AKI) – general term used to describe a sudden deterioration in renal function that occurs within 48 hours following the intravascular administration of iodinated contrast medium. CA-AKI may occur regardless of whether the contrast medium was the cause of the deterioration. CA-AKI is a correlative diagnosis.[1]

d. **Contrast-induced acute kidney injury (CI-AKI)** formerly known as contrast-inducedacute nephropathy (CIN). CI-AKI is a specific term used to describe a sudden deterioration in renal function that is caused by the intravascular administration of iodinated contrast medium; therefore, CI-AKI is a subgroup of CA-AKI. CI-AKI is a causative diagnosis.[1]

e. The diagnosis of AKI is made according to the kidney disease: Improving Global Outcomes (KDIGO) criteria if one of the following occurs within 48 hours after a nephrotoxic event (e.g., intravascular iodinated contrast medium exposure) [1]
   i. Absolute serum creatinine increase ≥0.3 mg/dL (>26.4 µmol/L)
   ii. A percentage increase in serum creatinine ≥50% (≥1.5 -fold above baseline)
   iii. Urine output reduced to ≤0.5 ml/kg/hour for at least 6 hours.

f. Referring to a doctor means referring to a specialist.

5. RESPONSIBILITIES

Requesting physician and the referring team should:

a) Ensure that the indication is appropriate for the imaging investigation requested.
b) Provide sufficient clinical information to radiology team including the LMP for female patient of reproductive age.
c) Optimize the patient for the imaging examination which includes but not limited to renal function, allergies, history of previous reaction, MRI checklist (for MRI examination) and medications.
d) Ensure no contraindication for the examination.
e) Obtain the necessary informed consent.
f) Be readily available to assist the radiology team if complications arise during the procedure and take over the subsequent management if necessary.

Radiologist:

a) Should justify the investigation and suggest other appropriate alternative investigation if necessary.
b) Prescribe contrast material and examination protocol.
c) Should be immediately available to furnish assistance and direction throughout the performance of the procedure [5,6]. This does not mean that the radiologist must be present in the room where and when the procedure is performed [5].
d) Recognize and treat adverse events related to contrast media administration including ensure referral to primary team if clinically indicated.

Radiology Medical Officer:

a) Take informed consent, ensure completion and safety of the document.
b) Reconfirm the allergy checklist.
c) Check for LMP for female patient of reproductive age.
d) Review relevant investigation results and act accordingly.
e) Ensure patency of the IV line.
f) Administer and supervise the injection of contrast media.
g) Recognize and treat adverse events related to contrast media administration including referral to primary team if clinically indicated.
h) Inform the radiologist in charge of the above adverse events.
i) Follow a pre-defined examination protocol or modified protocol according to the radiologist in charge.

Radiographers:

a) Reconfirm the allergy checklist.
b) Check for LMP for female patient of reproductive age.
c) Prepare the power injector and connection to the available IV line.
d) Administer oral contrast.
e) Administer IV contrast via power injector under radiology medical officer supervision/as per local guidelines.
f) Perform the examination following the protocols according to the local set up.
g) Understand the contraindications to intravascular injection of contrast media.
h) Recognize adverse events following contrast media administration.
i) Inform radiology doctor of the adverse events.
j) Inform patient when exam is completed and to ensure he/she is generally well post procedure to leave the department.

Radiology Staff Nurses:

a) Reconfirm the allergy checklist.
b) Check for LMP for female patient of reproductive age.
c) Check for the consent.
d) Check patency of the IV line or set IV line (if privileged)
e) Administer oral, rectal contrast, vaginal tampon (when indicated) and /or IV contrast. (as per local guidelines).
f) Understand the contraindications to intravascular injection of contrast media.
g) Recognize adverse events following contrast media administration.
h) Inform radiology doctor of the adverse events.
i) Remove the IV-line once examination is completed and ensure hemostasis.

Patients:

Provide accurate and complete information about their illnesses i.e., present symptoms, allergies, the use of medications prescribed/not prescribed, herbals and others, past illnesses, previous hospitalizations, and all other matters relating to their health.

The health care professional administrating the contrast medium should be by doctors or other privileged medical personnel. [32]

6. SPECIFIC PROCEDURE

6.0 Prescribing Contrast

A formal record of the decision to administer intravenous contrast agents should be made before the examination. How this is achieved will depend on local circumstances, but may include:

a) All special imaging investigations requiring intravenous contrast media should be requested by the referring specialist; however, request can be made by medical officer from the primary team after discussion and agreement by the requesting specialist in charge.
b) These requests should be vetted by the radiology medical officer / radiologist. Unsuitable requests or requests with insufficient clinical information can be rejected by the Radiology Department via the approval by the radiologist in charge. Suitable amendments can be made by the radiologist in charge after discussion and mutual agreement with the primary team.
c) The radiologist / radiology medical officer (if in doubt should consult with the radiologist in charge) shall approve the type and dosage of contrast media based on the guidelines. (Refer to the contrast media product guidelines)
d) Radiologist / radiology medical officer in charge should evaluate / screen patient for risk factors for adverse outcome to contrast injection. **Please refer to section 6.3 below**.
e) In patients with renal impairment consider alternative imaging methods.

6.1 Patient Information and Consent

The patient should always be fully informed and understand about the whole procedure. Appropriate patient information sheets should be available in the department. Guidelines for consent taking in patients going for radiological procedure that may require intravenous / intra-arterial contrast medium injection:

a) When to get consent?

For radiological procedure that may require contrast medium (CT, IVU, MRI, angiography, contrast enhanced mammogram, fluoroscopic procedures and contrast enhanced ultrasound).

b) Who to take consent?

The requesting doctor from primary team on the day of request, radiology doctor on the day of examination.

c) How to get consent?

The requesting doctor shall explain the patient's condition, the need for the investigation and how it is going to alter the management.
The radiology doctor shall explain the procedure itself and the possible complications.
The consent shall be taken from the patient him/herself. In the event he/she is not capable of doing so consent can be taken from next-of kin / legal guardian.

d) Duration of the validity of the consent?

The Malaysian Medical Council Guideline does not mention a time frame for duration of validity of consent. However, it recommends medical practitioners to remind the patients or take a new consent [4].

e) Where should the consent form be kept?

In the Record Unit of the hospital together with the examination report [5]

f) Use of a translator is advised if needed in elective procedures to assist in consent taking. This must be documented in the consent form.

6.2 Risk Stratification

6.2.1 Identifying Patients at Increased Risk for Contrast Media.

Assess risk for contrast reaction [1,2]

Essential information which should be sought from the patient before a contrast injection includes history of:

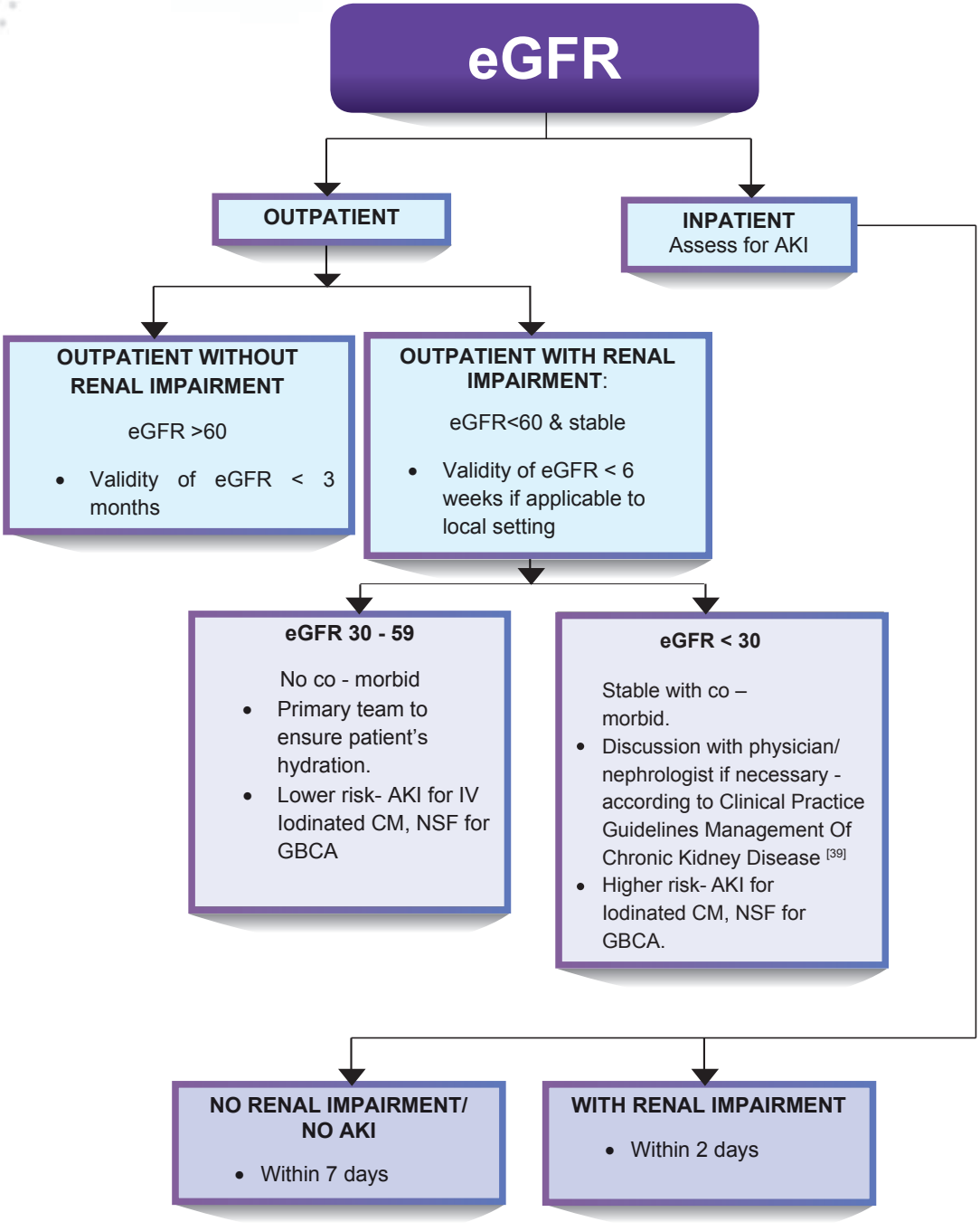
Age: > 50 years old, higher risk to CA-AKI. (adapted from references [1,18,32])	Asthma or allergies
Medication - Metformin, nephrotoxic drugs	Previous contrast reaction
Renal diseases- preexisting CKD, history or renal cancer/renal surgery, transplant, dialysis, single functioning kidney	Thyroid disease-primary team to assess for hyperthyroidism

Other underlying medical problems including but not limited to renal problems, diabetes and heart disease - physician consultation by primary team when necessary.

OTHER SPECIAL CASES	NORMAL eGFR	REDUCED eGFR
Multiple Myeloma	Should be well hydrated	Need physician/nephrologist consult
Sickle Cell Disease	Hydrate patient	
Phaeochromocytoma And Paraganglioma	• No special preparation for intravenous procedure for any GD-based contrast agent or iodinated contrast media. • Intra-arterial angiographic procedure, alpha- and beta-adrenergic blockade with orally administered drugs under the supervision of referring physician is recommended.	

RISK FACTORS FOR CI-AKI (IODINE BASED CONTRAST MEDIUM) (adopted and adapted from reference [2])	
Patient Related	• GFR less than 45 ml/min/1.73 m^2 before intra-arterial contrast medium administration with first pass renal exposure or in ICU patients. • eGFR less than 30 ml/min/1.73 m^2 before intravenous contrast medium or intra-arterial contrast medium administration with second pass renal exposure. • Known or suspected acute kidney injury.
Procedure Related	• Intra- arterial contrast medium administration with first pass renal exposure. • Large doses of contrast media. • High-osmolality contrast media. • Multiple contrast medium injections within 48-72 hours.
Precautionary Steps for Patient Related eGFR Factor in This Table:	• Keep the ratio of iodine dose (in gram iodine) / absolute eGFR (in ml/min) below 1.1. • Keep the ratio of contrast volume (in ml) / eGFR (in ml/ min/1.73m^2) below 3.0 (for a contrast concentration of 350mg iodine/ml) Calculation for the above - appendix G. • Use low kV techniques that allow for reducing contrast dose.
Disclaimer	• The decision to use concentration and volume according to the above calculation is up to the discretion of the in-charge radiologist, after discussing with the referring doctor. As the concentration and volume might not be of diagnostic value. • In certain clinical situations, the use of intravascular iodinated contrast medium of applicable concentration and volume may be necessary regardless of CI-AKI risk. Discussion with physician/ nephrologist is advised, informed high risk consent and document.

6.2.2 Validity Period of eGFR for Evaluation of Renal Function Prior to IV Contrast Administration (Iodine Based and GBCA) (adopted and adapted from references [1,2,7,9 ,17])



Currently, there is very little evidence that IV iodinated contrast material is an independent risk facto r for AKI in patients with eGFR ≥30 ml/min/1.73 m^2 [1,9]. Severe renal function impairment should not be regarded as an absolute contraindication to medically indicated iodinated contrast media administration in discussion with the primary team.

The decision whether to proceed with intravascular contrast media imaging examination rests on referring team and radiologist for all cases including eGFR < 30 ml/min/1.73 m^2.

The role of physician /nephrologist is to advise the optimization of patient's condition before receiving intravascular contrast media and to advise on post procedure care and monitoring if needed, should the primary team and radiologist decide to go ahead with the examination.
Referring team is to ensure patient is well hydrated and euvolumic before the administration of IV iodinated contrast accordingly to patient's condition.

6.2.3 In Elective Examination Measure eGFR (adapted from reference [2]):

Either one below (depending on local practice):

a) In all adult patients (18 years and above) or
b) In patients age above 50 years [32] and any adult patients with history of:
    - Renal disease (eGFR < 60 ml/min//1.73 m^2)
    - Kidney surgery
    - Proteinuria
    - Hypertension
    - Hyperuricemia
    - Diabetes Mellitus

Emergency examination [2]
Identify at-risk patients (see above) if possible:

a) Determine eGFR if the procedure can be deferred without harm to the patient. until the result is available
b) If eGFR cannot be obtained, follow the protocols for patients with eGFR less than 45 ml/min/1.73 m^2 for intra-arterial administration with first pass renal exposure and eGFR less than 30 ml/min/1.73m^2 for intravenous administration and intra-arterial administration with second pass renal exposure as closely as clinical circumstances permit.

To minimize occurrence of dehydration, fasting is generally not indicated prior to IV contrast examination except in certain situations. Please refer table below for recommendations [adapted and adopted from references [1, 2, 33, 34, 35, 36, and 37]).

Type of exam	Patient preparation	Common instruction
Group A I. MRI with IV contrast **EXCEPT for imaging of hepatobiliary system / pancreas** II. CT scan with IV contrast **EXCEPT CT scan abdomen and pelvis.**	• No fasting is required. Light meal is recommended. • Fluids are encouraged EXCEPT if patients are on fluid restrictions	For Group A & B • May take medication as usual except when there are special instructions from the primary team. • Patients with no fluid restrictions are recommended to drink at least 500ml of plain water before the CT scan and a total of 2L of water for 8 hours post CT scan. • Fluids are allowed pre-MRI (except for **MRI of the hepatobiliary system / pancreas)**. • Fluids are encouraged to post MRI for patients with no fluid restrictions. • Patients on fluid restriction are advised to follow referring doctor's instructions on fluid regime.
Group B I. Elective abdominal and pelvic CT with IV contrast media. II. Patients with asthma/ history of previous contrast reaction (if undergoing examination with the same class of contrast media) history of multiple allergies, a documented severe allergy requiring therapy. III. MRI of the biliary system/pancreas	Fasting prior to examination: • 4 hours – to solid food and nourishing fluid. Fasting prior to examination: 4 hours – to solid food and nourishing fluid.	

Group C I. Diagnostic or interventional procedures with intravascular contrast media II. Imaging examinations with IV contrast performed under general anesthesia or sedation	Fasting prior to IV contrast imaging procedure: • To solid food: 6 hours • To nourishing fluids: 4 hours • To clear fluids: 2 hours	As per Interventional Radiologist's / Anaesthesiologist's instructions

Note : (adopted and adapted from [33])

i. Fasting for more than 3 hours not only fails to reduce the volume of the gastric content but lowers the pH level thus placing patients at increased risk for aspiration pneumonia. However due to heterogenous fasting practices, a 4-hour fasting period prior to examination in Group B is agreed upon according to local consensus.
ii. Patients still need to fast prior to a contrast-enhanced CT examination of the abdomen and pelvis, since they would be unwilling to drink oral contrast medium with a full stomach.
iii. Diabetics should omit their morning dose of insulin or selected oral glucose lowering drugs (OGLDs) according to primary / treating doctor's instructions if they are fasting for a radiological examination.

6.2.4 Recommendation During Examination [2]

All Patients	• Use low- or iso-osmolar contrast media. • Use the lowest dose of contrast medium consistent with a diagnostic result. • For intra-arterial contrast medium administration with first pass renal exposure, keep either the ratio contrast media dose (in gram I) / *absolute* eGFR (in ml/min) < 1.1 or the ratio contrast media volume (in ml) / eGFR (in ml/min/1.73 m^2) < 3.0, when using contrast medium concentration of 350 mgI/ml.

6.2.5 Recommendation after the examination

At-Risk Patients	• Recommend primary team to manage post procedure care and monitoring. Discuss with nephrologist if necessary.

Note: No pharmacological prophylaxis (N-acetylcysteine, statins, renal vasodilators, receptor antagonists of endogenous vasoactive mediators or cytoprotective drugs) have been shown to offer consistent protection against CI-AKI. [1,2]

6.3 Interaction with Other Drugs and Clinical Test (adopted and adapted from references [1,2])

GENERAL RECOMMENDATION	
• Be aware of the patient's drug history. • Keep a proper record of the contrast agent injection (time, dose, name) • Do not mix contrast agents with other drugs in tubes and syringes	
DRUGS NEEDING SPECIAL ATTENTION	
Metformin	**Refer to section 6.5**
Nephrotoxic drugs e.g. Cyclosporine Cisplatin Aminoglycosides Non steroid antiinflammatory drugs	Stopping nephrotoxic drugs before administering contrast agents is generally recommended when applicable. (Primary team's / physician's decision)
ß-blocker (Beta blocker)	ß-blockers may impair the management of bronchospasm and the response to adrenaline. Due to the modest increased risk, restricting contrast medium use or premedicating solely based on ß-blocker use is not recommended. Patients on ß-blocker therapy do not need to discontinue their medication (s) prior to contrast medium administration.
Interleukin-2	Refer to delayed hypersensitivity reaction: • Interleukin-2 treatment • A specific risk of delayed skin rash is associated with interleukin-2 therapy. Oncologists should be informed that they should always indicate if the patient is on this drug when referring them for a contrast injection.

ISOTOPE STUDIES AND/OR TREATMENT [20]	
Thyroid	• Patients undergoing therapy with radioactive iodine should not have received iodine-based contrast medium for at least 3 months before treatment. • Isotope imaging of the thyroid should be avoided for 3 months after iodine-based contrast medium injection.

6.4 Renal Adverse Reactions to Gadolinium-Based Contrast Media Reaction – Examinations [2]

The risk of CI-AKI is very low when gadolinium-based contrast agents are used in approved doses. In patients with reduced renal function, refer to gadolinium section on Nephrogenic Systemic Fibrosis (NSF).

6.5 Patients with Diabetes Mellitus Taking Metformin - Physician Consult / Primary Team Management [1,2]

6.5.1 Iodine-Based Contrast Media

PATIENT'S RENAL FUNCTION	RECOMMENDATION
Category 1 eGFR > 30 ml/min/1.73 m2) with no evidence of AKI, receiving either intravenous contrast medium or intra arterial contrast medium with second pass renal exposure.	No need to discontinue
Category 2 i. eGFR < 30 ml/min/1.73 m^2 ii. AKI iii. Receiving intra-arterial contrast medium with first pass renal exposure	Temporarily discontinue at the time of or prior to the procedure. Withhold metformin for 48 hours subsequently. Reinstitute if renal function normalized to patient's baseline reading)

6.5.2 Gadolinium-Based Contrast Media [1,2]

No special precautions are necessary when diabetic patients on metformin are given gadolinium-based contrast agent.

6.6 Recommendations for Contrast Use (Iodine-Based and Gadolinium-Based) in Patients at Increased Risk of Contrast Reaction (adopted and adapted from references [8 & 10])

EVENT	ACTION	RESPONSIBILITY
History of previous contrast reaction: - 1) Exact nature of the previous reaction 2) Specific compound used.	Re-examine the need for the use of contrast e.g. unenhanced study and offer alternatives such as other imaging modalities. Assess the risk–benefit ratio If examination still deems necessary: - use a different contrast compound	Radiologist, radiology medical officer, and primary team.
	Premedication (refer 6.7). Maintain close medical supervision. Leave the cannula in place and observe the patient for 30 minutes after the procedure.	Primary team, privileged radiology personnel
Asthma. Determine: True asthma or COPD.		Primary team, radiologist, and radiology medical officer
• Uncontrolled	Defer if examination not urgent and refer for appropriate medical therapy.	
• Well controlled	Reassess the need for intravascular contrast or unenhanced study/ other imaging modality	
• If IV contrast medium is necessary	Premedication **(refer 6.7)** Use a non-ionic low or iso-osmolar agent [if iodine contrast medium]. Maintain close medical supervision. Leave the cannula in place and observe the patient for 30 minutes after the procedure.	Primary team, radiologist, radiology medical officer Privileged radiology personnel

EVENT	ACTION	RESPONSIBILITY
Multiple allergies or a documented severe allergy requiring therapy. Determine the nature of allergies.	Reassess the need for intravascular contrast or unenhanced study/ other imaging modality: - Premedication **(refer 6.7)** Use a different non-ionic low or iso-osmolar agent. Maintain close medical supervision. Leave the cannula in place and observe the patient for 30 minutes after the procedure.	Radiologist, radiology medical officer and primary team Primary team, radiologist, radiology medical officer Privileged radiology personnel

6.6.1 Recommendation:

Patients with prior allergic-like or unknown-type contrast reactions to known contrast medium.	Changing contrast media within the same class e.g., one iodinated medium for another, may help to reduce the likelihood of a subsequent contrast reaction [1].

6.7 Premedication with steroid therapy to reduce risk of contrast reaction (adopted and adapted from reference [1])

a) Indications for premedication
Given the trade-offs between what is known and not known with respect to the benefits and harms of premedication, premedication may be considered.

b) Patient Selection and Preparation Strategies before Contrast Medium Administration (Flow charts refer to **Appendix B**).

EVENT	ACTION	RESPONSIBILITY
Elective • Prior allergic-like or unknown-type contrast reaction to the same class of contrast medium (e.g. iodinated–iodinated).	Standard oral preparation regimen: Prednisolone 40 mg, 12 and 2 hours prior to examination.	Primary team
Missing one or more doses of premedication	If premedication is being used, a guiding principle is to have a minimum of 4-5 hours of corticosteroid therapy prior to contrast medium exposure, with repeat doses every 4-8 hours. Scenarios as below:	Radiologist and radiology medical officer
	Missed 12 hours premedication but taken 2 hours premedication (1st dose). Suggestion: 2nd dose given after 4 hours of the 1st dose. CTscan: 4 hours after 2nd dose.	
	Missed 2 hours premedication but taken the 12 hours (1st dose) premedication: Suggestion: Postpone the case if patient comes after 9am and agreeable for the postponement. If patient comes before 9am e.g. Arrival 8am: Stat dose (2nd dose) and start the case 4 hours after the 2nd dose:	
	Arrival 9am - Give stat dose on arrival. 4 hours after the stat dose: 2nd dose given. Start CT 4 hours after the 2nd dose.	

EVENT	ACTION	RESPONSIBILITY
Urgent Anticipated to adversely delay care decisions or treatment	A dose of IV Hydrocortisone 200mg can be given with a minimum duration of 4-5 hours interval may be efficacious [1] If it is not possible to wait 4-5 hours following IV corticosteroid before urgent imaging is done, suggest IV hydrocortisone 200mg is given immediately or 1 hour before examination according to urgency of the case as there is no evidence to support the efficacy of a single dose of premedication given 2 hours or less – be it via oral or IV	Primary team, radiologist and radiology medical officer
On chronic corticosteroid therapy • Patient on therapeutic dose. • Patient is on simple replacement (not therapeutic) dose	Modify premedication, management is individualized. Dose of premedication is reduced according to patient's therapeutic dose. Follow the timing regime for premedication (12 and 2 hours prior to imaging)	Primary team
Prior allergic-like and known type contrast reaction to the same class of contrast medium (e.g. iodinated - iodinated)	Combination of premedication with a change of contrast medium.	Primary team, radiologist and radiology medical officer

6.8 IV Access for Contrast Injection and Guidelines to Reduce Risk of Contrast Medium Extravasation [11,12]

a) Utilize the appropriate gauge needle for the flow rate. Please refer to the recommendation by the manufacturer for both flow rate and the pressure. An inappropriate high flow rate or pressure may cause rupture of the said branula and can cause contrast extravasation.

b) Preferred venous access site for power injection: antecubital or large forearm vein standard 20G or larger peripheral IV catheter located in an antecubital, upper forearm is preferred. The use of deep brachial intravenous catheters should be avoided because of the markedly higher relative risk of extravasation than antecubital IV placement [24, 26, 27] . When 22G branula is necessary, use a reduced injection rate of < 3 ml/sec in adults (2.0cc / sec in pediatrics). For 22G in the wrist/hand use a reduced rate of injection ≤ 1.5 ml/sec (hand injection preferred, pressure with caution) [31]

c) Contrast is recommended to be injected at foot veins at 1 ml/s within 100 psi. Multi - phase exams are not recommended to be performed using intravenous access in hand veins or lower extremity.

d) For these sites of IV access, only hand injection is allowed:
   - External jugular vein (secondary to risk of neck hematoma from extravasation).
   - 24G peripheral IV catheter.
   - Short IV cannula placed in the internal jugular vein.

   The injection should be performed by radiology medical officer / radiologist / medical officer of primary team (depending on local setting).

e) Single lumen power rated sheath in the neck (in the internal jugular vein only) or groin can be used for power injection (3-5 ml/sec < 300 psi): as recommended by the manufacturer.

f) Dialysis catheters: NOT to be used for IV contrast. Dialysis catheters should never be accessed without the explicit approval of the responsible attending nephrology fellow/hematology/oncology and document as there is risk of catheter rupture and arrhythmia. Should be used according to the manufacturer's guidelines by appropriately trained personnel.

6.9 Steps in the Preparation and During Injection of Contrast Media

EVALUATION PROCESS	ACTION	RESPONSIBILITY
IV access (for hand or mechanical injection) prior to injection of IV contrast.	Check patency	Privileged radiology personnel
Power injector	Careful preparation: To minimize the risk of contrast medium extravasation or air embolism	Radiographer
Injector for injection of contrast	Connect	Radiographer
Patient's instruction to notify the radiographer/radiology doctor for: changes in sensation, pain or swelling at the injection site	Communicate	Privileged radiology personnel
Initial injection of contrast media via power injector or hand injection	Observe patient in the CT room for any extravasation during injection and for any allergic reactions	Doctors, privileged radiology personnel
Post examination	Observe patient for any allergic reactions for the first 30 minutes after injection of contrast media	Privileged radiology personnel

6.9.1 Warming Iodine-Based Contrast Medium Before Administration [2]

Based on clinical observation, this appears to make the patient more comfortable, reduces viscosity and may reduce risk of contrast medium extravasation.

6.9.2 Extra Vascular Administration of an Iodine-Based Contrast Medium

When absorption or leakage into the circulation is possible such as in hysterosalpingogram studies, similar precautions as for intravascular administration are to be taken.

6.10 Protocol for a Standard Central Venous Catheter (CVC) Use with Power Injectors [13]

CVC with power injector compatibility should only be used according to manufacturer's recommendation. Otherwise, only hand injections are allowed.

CAUTION :

Should use a large size sterile syringe. Recommended for adults is 50cc syringe. For pediatrics use an appropriate size sterile syringe for the volume used. (Hand injection particularly using small syringes can generate high pressures)
Pressure generated by hand is unknown and cannot be limited.

Before injection [28] :

Confirmation of the CVC's Tip Placement : Either one below could be used.

- CT topogram that covers the CVC : determine the line position. The tip should be at lower SVC. For multilumen CVC, the distal lumen should be used.
- In very rare situations, unenhanced axial CT slices through the line tip can be used.

Contraindication for CVC injection: A curve at the end of the CVC is highly suggestive of impending perforation.

Refer **Appendix C** & **Appendix D** for the workflow of contrast injection via CVC.

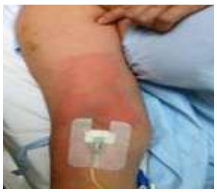
6.11 Contrast Medium Extravasation [2]

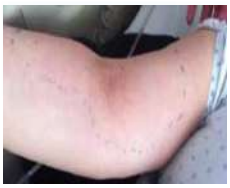
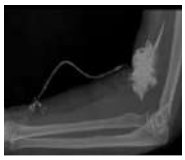
Type of injuries	• Most injuries are minor. • Severe injuries include skin ulceration, soft-tissue necrosis, and compartment syndrome.
RISK FACTORS	
Technique-related	• Use of a power injector. • Less optimal injection sites include lower limb and small distal veins. • Large volume of contrast medium. • High-viscosity contrast media.
Patient-related	• Inability to communicate. • Fragile or damaged veins. • Arterial insufficiency. • Compromised lymphatic and/or venous drainage. • Obesity.

To reduce the risk	• Intravenous techniques should always be meticulous using an appropriate sized plastic cannula placed in a suitable vein to handle the flow rate used during the injection. • Test injection with normal saline. • Use non-ionic in cases of iodine-based contrast medium.
Management	• Document the extravasation. • Conservative management is adequate in most cases. Limb elevation Ice packs Careful monitoring • If a serious injury is suspected, seek the advice of a surgeon

6.11.1 Contrast Extravasation Management (adapted and adopted from references [1, 14]).

Refer **Appendix E**

CONTRAST EXTRAVASATION		
EVENT	**ACTION**	**RESPONSIBILITY**
	Stop injection.	Radiographer
	Slowly remove the intravenous needle while aspirating gently	Privileged radiology personnel
	Notify the radiology nurse, radiology medical officer and radiologist	Privileged radiology personnel
	Notify ordering doctor/referring team	Radiologist, radiology medical officer
	Mark the affected area and the site of measurement of the affected limb	Radiology medical officer, radiology nurse
	Measure circumference of the affected and contra lateral limb	Radiology medical officer, radiology nurse

	Medical Treatment: • Elevation of the affected limb above the level of the heart • Application of cold compress (for 15 minutes, with an interval of every 30min) without direct contact skin with the ice • Monitor affected limb and severity for at least 2 hours	Radiology medical officer, radiology nurse
	Immediate orthopedic/surgical consult (depending on site) for the following: a) Altered tissue perfusion, changes in sensation and skin ulceration, necrosis, or blistering. b) Persistent pain, increase swelling/pain within 2 hours. c) Worsening passive or active range of motion of the elbow, wrist, or fingers or intense pain when affected muscles are passively stretched	Radiologist, radiology medical officer, primary team
	Radiograph AP & Lat of limb involved. (Optional: case to case basis)	Radiologist (decision) radiographer (perform)
	Documentation In EMR/Patient's Note: • Location • Radiograph & type of extravasation (optional) • Amount of contrast • Patient's symptoms & clinical findings • Severity of extravasation Requires: observation/referral/ admission • Radiology personnel: Involved Radiologist, medical officer,nurse & radiographer	Radiologist, radiology medical officer

Management of extravasation according to severity:		
Mild	• Allow home (outpatient) Provide leaflet and explanation (appendix M) Please refer to Appendices E (Extravasation flow chart and L (Audit tool CM Extravasation)	Radiologist (decision) Radiology medical officer, radiology nurse
	• Follow up next day via phone call/ appointment, inform radiologist in charge & document.	Radiologist, radiology medical officer, radiology nurse
Moderate	a) Outpatient: • Refer to Emergency Department/primary team according to local context. • Follow up next day & document	Radiologist, radiology medical officer
	b) Inpatient: • Refer to primary team. • Follow up next day & document.	Radiologist, radiology medical officer
Severe	a) Outpatient: • Refer to orthopedic/surgical (depending on extravasation site) and primary team. • Follow up next day & document.	Radiologist, radiology medical officer
	b) Inpatient: • Refer to orthopedic/surgical (depending on extravasation site) and primary team. • Follow up next day & document.	Radiologist, radiology medical officer

Keynote:

Incident report will be done according to inclusion and exclusion criteria of NIA & KPI Guidelines.
An incident report shall be completed by the involved radiology personnel **(Appendix K)**
The extravasation audit tool **(Appendix L)** should be completed by radiology nurse / medical officer to track extravasation follow-up.

6.12 The Treatment of Reactions Adult and Pediatric:

Please refer to management of anaphylactic iodinated contrast media reaction of appropriate manual e.g. [22]

6.12.1 Recording and Investigation of Significant Suspected Contrast reactions (flow chart) – **(Appendix F)**

6.12.2 Patient Education is provided. (patient education / information leaflet) **(Appendix J)**

6.13 Late Adverse Reactions: refer 6.3 on Interleukin 2

6.14 Very Late Adverse Reactions (adopted and adapted from reference [2])

Definition : an adverse reaction which usually occurs more than 1 week after contrast agent injection

6.14.1 Very Late Adverse Reactions to Iodine-Based Contrast Media (adopted and adapted from reference [2]

THYROTOXICOSIS	
At risk	• Patients with untreated Graves' disease. • Patients with multinodular goiter and thyroid autonomy, especially if they are elderly and/or live in an area of dietary iodine deficiency.
Not at risk	Patients with normal thyroid function.
Recommendations	• Iodine-based contrast media should not be given to patients with manifest hyperthyroidism. • Further assessment should be done by the primary team. • The patient's condition should be optimized before IV contrast media if situation allows. • If urgent risk vs benefit should be discussed between primary team/radiologist and endocrinologist/physician. • If deemed necessary, high-risk consent obtained and document in the medical notes. • Patients at risk should be closely monitored by endocrinologists / physician after iodine-based contrast medium injection.

6.14.2 Late Gadolinium Based Contrast Medium Reaction:

Nephrogenic Systemic Fibrosis (NSF) [7,8]

Definition	Nephrogenic systemic fibrosis (NSF) is a disease that involves fibrosis of skin, joints, eyes, and internal organs associated with exposure to some gadolinium-based contrast media (GD-CM) in patients with impaired renal function. NSF may develop from the day of exposure to two or three months, up to years later.
Clinical Features	• Pain • Pruritis • Swelling • Erythema Usually starts in the legs
Presentation	• Thickened skin and subcutaneous tissue-'woody' texture and brawny plaques • Fibrosis of internal organs • Contractures • Cachexia • Death, in a proportion of patients
Patient-Related Risk Factors	
Higher Risk [1,7,8]	• Patients with CKD 4 & 5 [GFR]<30ml/min/1.73m^2 • Acute kidney injury • Patients on dialysis
Lower Risk [1,7,8]	• Patients with CKD 3 [GFR] 30-59ml/min/1.73m^2 • Children < 1 year (due to immature renal function)
Note : • NSF has not been reported in patients with eGFR >60 ml/min/1.73m^2 • The role of other possible co-factors is not proven. • In the absence of specific information, it seems wise to manage pregnant patients (any status of renal function), in the same way as children aged less than one year to protect the fetus. • Following restrictions on the use of linear chelate GBCAs in patients with impaired renal function, no new cases related to exposure to the agents have been reported in Europe [8]	
Contrast Medium-Related Risk Factor [2] Less stable GD-CM (linear agents) NSF has occurred following the administration of:	

High Risk	• Omniscan (Gadodiamide, non-ionic linear chelate) • Magnevist (Gadopentetate dimeglumine, ionic linear chelate) • OptiMARK (Gadoversetamide, nonionic linear chelate)
Medium Risk	• Multihance (Gadobenate dimeglumine, ionic linear chelate) • Primovist (Gadoxetate disodium, ionic linear chelate)
Low Risk	• Gadovist (Gadobutrol, non-ionic macrocyclic chelate) • Dotarem (Gadoterate meglumine, ionic macrocyclic chelate) • Prohance (Gadoteridol, nonionic macrocyclic chelate)
Note : The following risk minimization measures should be used for GBCAs (adapted from the current Medicines and Healthcare products Regulatory Agency (MHRA) ***Caveat :*** Information on NSF and its relationship to GBCA administration continues to evolve, the summary included here represents the most recent opinions of the ACR committee on drugs and contrast media, ESUR CM guidelines version 10 and other major guidelines customized to local context. Revisions of this document may also occur due to future development and change.	
Renal function monitoring [adapted from references 8,32]	Important to screen • Patients age > 50 years • Patients with chronic diseases, e.g. diabetes, which are associated with renal failure
Patient with renal impairment [8]	• Avoid administering GBCAs in acute kidney injury while creatinine is rising. • Patients with moderate chronic renal impairment (eGFR 30- 59ml/min/1.73m2), if clinically indicated, a single lowest dose possible should be used and should not be repeated for at least 7 days. • Patients with severe chronic renal impairment (eGFR<30ml/min/1.73m^2) or acute renal impairment, use a low-risk agent. Use with CAUTION and if clinically indicated. For a medium risk agent, (such as for liver imaging), a single lowest dose can be used (not exceeding 0.1 mmol/kg body wt) and should not be repeated for at least 7 days.
Haemodialysis [2,8]	No evidence to support the initiation of haemodialysis for prevention or treatment of NSF in patients not already undergoing haemodialysis. Patients already established on dialysis should be dialyzed promptly/ as soon as possible after contrast administration

Recording of the agent used [8]	When available, 'peel-off' tracking labels found on the vials, syringes or bottles should be attached or scanned into the patient's record to maintain an accurate note of the name and batch of the gadolinium contrast agent used. Suspected adverse reactions should be reported
Pregnancy and lactation [1,2,8]	**PREGNANCY** Little human data regarding the use of GBCAs in pregnant women. GBCAs should not be used during pregnancy, unless there is a very strong indication for enhanced MR. The lowest possible dose {to achieve diagnostic results} of a macrocyclic gadolinium contrast agent with lowest risk of NSF may be used. **LACTATION** A very small percentage of the injected dose of GBCA enters the breast milk and virtually none is absorbed across the normal gut. The continuation or cessation of breast feeding for 24 hours should be at the discretion of the lactating mother in consultation with the clinician.

6.15 Special Consideration

6.15.1 Pregnancy and Lactation [adapted from reference 2]

IODINE-BASED CONTRAST MEDIA		GADOLINIUM-BASED CONTRAST AGENTS
Pregnancy	In exceptional circumstances, when contrast-enhanced imaging is essential, iodine-based contrast media may be given.	As in table 6.14.2 above under this topic
	Post-examination, thyroid function should be checked in the neonate during the first week	Post-examination no neonatal tests are necessary.
Lactation	Breast feeding may be continued normally	As in table 6.14.2 above under this topic
Pregnant with renal impairment	See renal adverse reactions. No additional precautions are necessary for the fetus or neonate.	If possible, avoid administer gadolinium-based contrast agents.

Note: Each case should be reviewed carefully and discussed between the referring doctor and the radiologist. GBCA should be administered only when there is a potential significant benefit that outweighs the risks. In pregnant patients with severely impaired renal function, the same precautions should be observed as in non-pregnant patients. [1]

Document the following in the radiology report or the patient's medical record [1]

- That information obtained from the MRI study cannot be acquired without the use of IV contrast or by using other imaging modalities.
- That the information needed affects the care of the patient and / or fetus during the pregnancy
- That the referring physician is of the opinion that it is not prudent to wait to obtain this information until after the patient is no longer pregnant.
- Informed consent should be obtained from the patient after discussion with the referring physician.

6.15.2 Special Consideration in Pregnancy [1]: Premedication and Resuscitation

ISSUES	RECOMMENDATION	COMMENT
Use of Corticosteroid in pregnancy	Generally safe	Otherwise indicated, premedication to reduce the risk of contrast media reaction shall not be withheld.
Management of contrast reaction in pregnant patients	Generally, the same as that of contrast reaction in non-pregnant patient with minor additions	
Hypotension	Place patient in the left lateral decubitus position or position patient supine with a leftward tilt using a wedge.	
If cardiac compression is required	Best performed in a supine position	

6.15.3 Dialysis and Contrast Medium Administration [2]

All iodine- and gadolinium-based contrast agents can be removed by hemodialysis or peritoneal dialysis. However, there is no evidence that hemodialysis protects patients with impaired renal function from CI-AKI or nephrogenic systemic fibrosis.

PATIENTS ON DIALYSIS [2]	
Patients on hemodialysis	Iodine-based contrast medium • Correlation of time of the contrast medium injection with the hemodialysis session is unnecessary. • Hemodialysis session to remove contrast medium is unnecessary.

	Gadolinium-based contrast agent • Correlation of time of the contrast agent injection with the hemodialysis session is recommended. • Hemodialysis session to remove contrast agent as soon as possible after it has been administered is recommended.
Patients on continuous ambulatory peritoneal dialysis	Iodine-based contrast medium • Hemodialysis to remove the contrast medium is unnecessary.
	Gadolinium-based contrast agent • The need for hemodialysis should be discussed with the referring physician

Note: Patients with end stage renal disease on chronic dialysis. If a contrast-enhanced cross - sectional imaging study is required in an anuric patient with no residual renal function, it would be reasonable to consider administering iodinated contrast media and performing a CT rather than an MRI, assuming the anticipated diagnostic yield is similar. [1]

Patients undergoing dialysis who produces more than 1-2 cups of urine/day(100ml) should be considered as non anuric and treated as high-risk patients similar to patients with AKI or eGFR < 30ml/min/1.73m^2 who are not undergoing hemodialysis.[1]

6.16 Pediatric Use of IV Contrast Agent (adopted and adapted from [1])

6.16.1 Safety Consideration: Similar to, but not the same as, in adults

6.16.2 Risk Stratification: -

6.16.2.1 Serum Creatinine / eGFR Testing

Generally, is not indicated. Exception: Renal and heart impairment where a pediatric referral and assessment are needed prior to the IV contrast imaging study.

6.16.2.2 Specific Attention

Contrast agent dose must be adjusted for patient age and weight.
Age-specific normal values of serum creatinine etc. should be used.
For iodine-based contrast media, non-ionic agents should be used.
For gadolinium-based contrast agents, high-risk agents should be avoided.
Refer to manufacturer's recommendation for contrast usage suitability.

6.17 Prevention of Contrast – Induced Nephrotoxicity in At-Risk Children

a) Risk factors for contrast-induced acute kidney injury (CI-AKI) in children are thought to be like those in adults. Unfortunately, there are no established evidence-based guidelines for the prevention of CI-AKI in children with impaired renal function. Strategies described in adults should be considered when using IV iodinated contrast media in children with renal dysfunction.
b) Alternative imaging should be used if the clinical question can be answered such as ultrasound / non contrasted CT / MR with or without gadolinium-based contrast medium.

6.18 Incidence of Allergic-Like Reactions and Prevention in Children

a) Infants and young children require close observation during and immediately following IV contrast medium administration, as they are unable to verbalize reaction related discomfort or symptoms. Allergic-like reactions to contrast media in children are rare.
b) General guidelines for the prevention of allergic-like reactions in children are similar to those used for adult patients. Premedication protocol shall be referred to referring pediatric team

6.19 Nephrogenic Systemic Fibrosis and Gadolinium-Based Contrast Media in Children

a) There are no evidence-based guidelines for the prevention of NSF in children. Adult guidelines are recommended to identify at-risk patients and administer gadolinium-based contrast media in the presence of impaired renal function.
b) Advise to avoid the use of a high - risk gadolinium agents in very young children (e.g neonates younger than 4 weeks of age). Although there has been no reported case of NSF in a very young child to date, caution should be used when administering these contrast agents, especially to preterm neonates and infants [25] due to renal immaturity and potential glomerular filtration rates under 30 mL/min/1.73m2 [26]
c) The use of IV gadolinium-based contrast media in children of all ages should be justified and the benefit of administration should outweigh potential risks.

6.20 Other Unique Issues in Children

a) Neonates and infants:

Small volumes of contrast media administered (1.5 to 2 mL/kg.)
A slower injection rate (compared to that used in older individuals) may be useful to prolong intravascular enhancement.
Therefore, timing of image acquisition is important.

b) Tenuous access: Strongly consider hand injection to minimize risk of vessel injury and extravasation. Individuals cannot effectively communicate so particular attention should be paid to the injection sites.

c) Verification should be done that any catheter to be utilized for bolus contrast material instillation can tolerate the anticipated injection. It is also important to ensure that the pressure used does not exceed the catheter's pressure rating.

7. Appendices

Appendix:

A. FAQ (Frequently Asked Questions)

B. Patient Selection and Preparation Strategies before Contrast Medium Administration

C. Flowchart for Intravenous Contrast Injection in CT via Central Venous Catheter by Power Injector

D. Flowchart for Intravenous Contrast Media Injection in CT via Central Venous Catheter by Hand Injection

E. In The Event of Extravasation (Flowchart)

F. Recording and Investigation of Significant Suspected Contrast Reaction (Flowchart)

G. Example of calculation: iodine gm and volume given in compromised renal function

H. "Consent Form "*Keizinan - Prosedur Radiologi Yang Memerlukan Suntikan Media Kontras berserta dengan Borang Permohonan Pemeriksaan Radiologi* PER.SS-RA301(Pind.1/2018)

I. Information Regarding Patient's Early Allergic Reaction to Intravascular Contrast Media.

J. Patient Information Regarding Early Allergic Reaction to Intravascular Contrast Media (Patient's Copy)

K. Incidence of Contrast Media Extravasation at Radiology Department

L. Audit Tool CM Extravasation.

M. *Borang Informasi* Extravasation *Pesakit*

Appendix A (adopted, adapted from reference [2])

FAQ Frequently Asked Questions (This serves as a guideline. This should be tailored by the primary team and radiologists in charge according to the clinical circumstances and needs)

i. Can iodine- and gadolinium-based contrast agents safely be given on the same day for routine examinations?
Efficient practice may involve giving iodine- and gadolinium-based contrast agents for enhanced CT and MR on the same day. To reduce any potential for nephrotoxicity the following are recommended:

   a. Patients with normal renal function or moderately reduced (GFR > 30 ml / min / 1.73 m^2).
   75 % of both gadolinium- and iodine-based contrast agents are excreted by 4 hours after administration. There should be 4 hours interval between injections of iodine- and gadolinium-based contrast agents.

   b. Patients with severely reduced renal function (GFR < 30 ml/min/1.73 m^2 or on dialysis).
   There should be 7 days interval between injections of iodine- and gadoliniumbased contrast agents.

Note: Gadolinium-based contrast agents attenuate X-rays well and may be misinterpreted on CT when they have been excreted into the urinary tract. For abdominal examinations, enhanced CT should be done before enhanced MR. For chest and brain examinations, either CT or MR may be done first.

ii. How long should there be a gap/interval between two iodine-based contrast medium injections for routine examinations?

   a. Patients with normal or moderately reduced renal function (GFR>30ml/min/1.73m^2).
   75 % of iodine-based contrast medium is excreted by 4 hours after administration. There should be 4 hours interval between injections of iodine-based contrast medium.
   b. Patients with severely reduced renal function (GFR < 30 ml/min/1.73 m^2).
   There should be 48 hours interval between injections of iodine-based contrast medium.
   c. Patients on dialysis.
   If there is remnant renal function there should be at least 48 hours interval between injections of iodine-based contrast medium.

iii. How long should there be between two gadolinium-based contrast agent injections for routine examinations?

   a.. Patients with normal or moderately reduced renal function (eGFR > 30 ml / min / 1.73 m^2).
   75 % of extracellular gadolinium-based contrast agents are excreted by 4 hours after administration. There should be 4 hours interval between injections of gadolinium-based contrast agent.

b. Patients with severely reduced renal function (eGFR < 30 ml/min/1.73 m^2) or on dialysis:
There should be 7 days interval between injections of gadolinium-based contrast agent.

iv. Is there any cut off age in pediatrics when power injector can be used:
Currently, no age limit. General guide: rate of injection depends on size of branula especially for CTA e.g. smallest branula size 24 (yellow), flow rate is 1mls / sec.

v. If a patient is allergic to oral prednisolone what is the alternative in premedication?

a. Betamethasone or deflazacort or dexamethasone can be used as alternatives [15]
Recommended in ACR 2020 contrast media guidelines if patient is allergic to methylprednisolone alternative that can be used is Dexamethasone sodium sulfate (e.g., Decadron ®) 7.5 mg IV immediately, and then every 4 hours until contrast medium administration.

Note: Methylprednisolone is also classified as a category C drug and carries a small risk to the fetus for the development of a cleft lip if used before 10 weeks of gestation [1]

b. No premedication but consider alternative imaging e.g. unenhanced MRI or ultrasound if clinical answer can be achieved.

vi. Permissible Doses - In Cases for CT And Angio on The Same Day
Risk of development of CI-AKI increases when multiple doses of IV CM is administered within a short period of time with intervals shorter than 24 hours, and it is to be avoided except in urgent situations.

a. As the volume of contrast administered goes up, the risk of nephrotoxicity probably increases (allergic-like reactions are independent of dose) It is believed that a total dose of 200ml or less of any of the department's iodinated contrast agents is well within the safety zone for patients without specific risk factors for nephrotoxicity. [30]
b. The question of a "maximum" allowed dose is more difficult, as the risk-benefit ratio must always be taken into account (i.e. there is no fixed maximum if the potential benefit outweighs the potential risk). The FDA package insert for Ultravist-370 states that the "maximum recommended total dose of iodine in adults is 86 grams". The FDA package insert for Visipaque states that the "maximum recommended total dose of iodine is 80 grams". Using these recommendations, it is suggested that the approximate maximum volumes of iodinated contrast in should be as follows:

- 285 ml of Omnipaque-300
- 250 ml of Lopamidol 300(Mims)

245 ml of Omnipaque-350
Can refer to Rx List.

- These volumes are not rigid and may be adjusted as warranted by the clinical situation and patient's condition, including risk factors for nephrotoxicity [30]

c. These recommendations don't specify the time frame over which the contrast is given, except in unusual circumstances, therefore it is probably best to stay within the recommended maximums within any 24 to 48 hour period. It is generally accepted that contrast material can again be administered after 72 hours if renal function remains unaltered, but this is based on limited data. [30]
d. Dose adjustments and alternate studies should be considered for patients who are at risk for nephrotoxicity (see prior CI-AKI guidelines). It is not advisable to use too low a dose as to result in an inadequate study because then it would mean that patient has been subjected to additional risk without receiving any benefit from the suboptimal study. [30]
e. Decision to administer closely spaced contrast-enhanced studies is clinical and subjective, with high-risk patients (e.g., Stage IV and Stage V chronic kidney disease, AKI) treated with greater caution than the general population. [1]

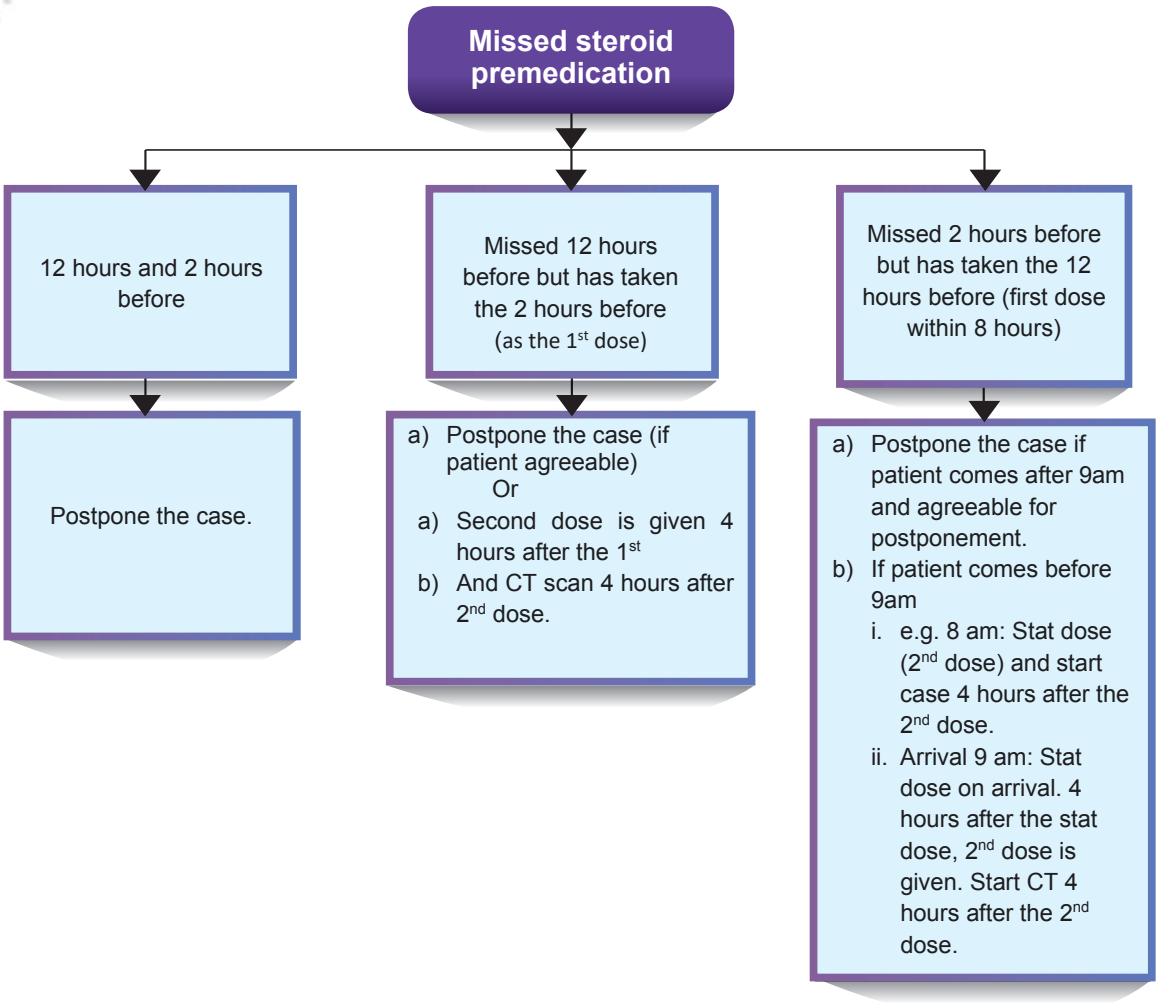
In patients with compromised renal function: please refer to **Appendix G**.
EXAMPLE OF CALCULATION: iodine gm and volume given in compromised renal function.

vii. If extravasation happens during IV contrast CT examination, should the examination be postponed or continue with new IV line?

a. In all cases, a patient's preference should take precedence.
b. In all cases the extravasation should be treated and managed as soon as possible.
c. In elective examinations, it is recommended to postpone the examination on a case-to-case basis.
d. In an emergency where information from the CT scan with IV contrast is vital, then the examination should proceed.

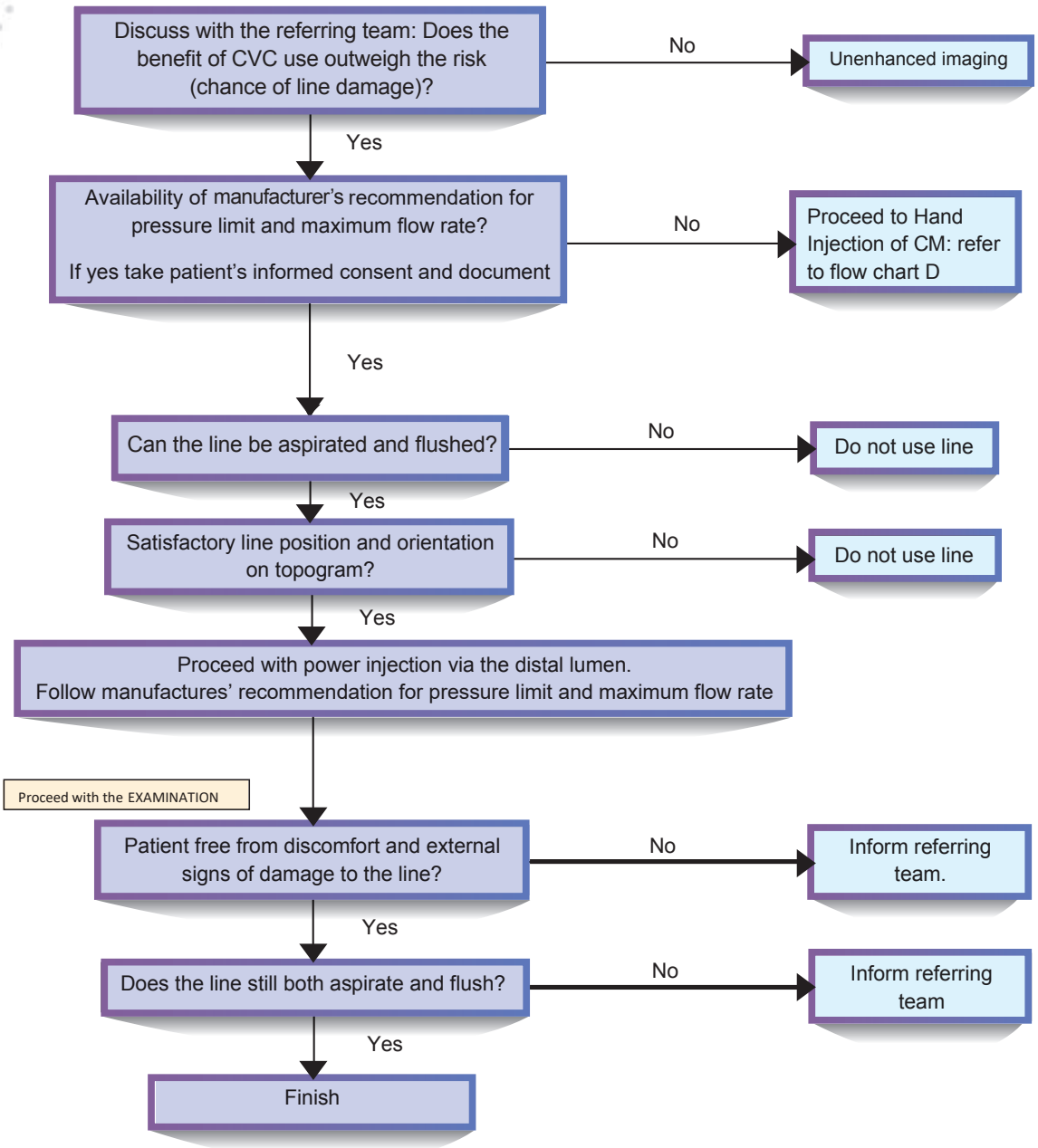
Appendix B

Patient Selection and Preparation Strategies before Contrast Medium Administration



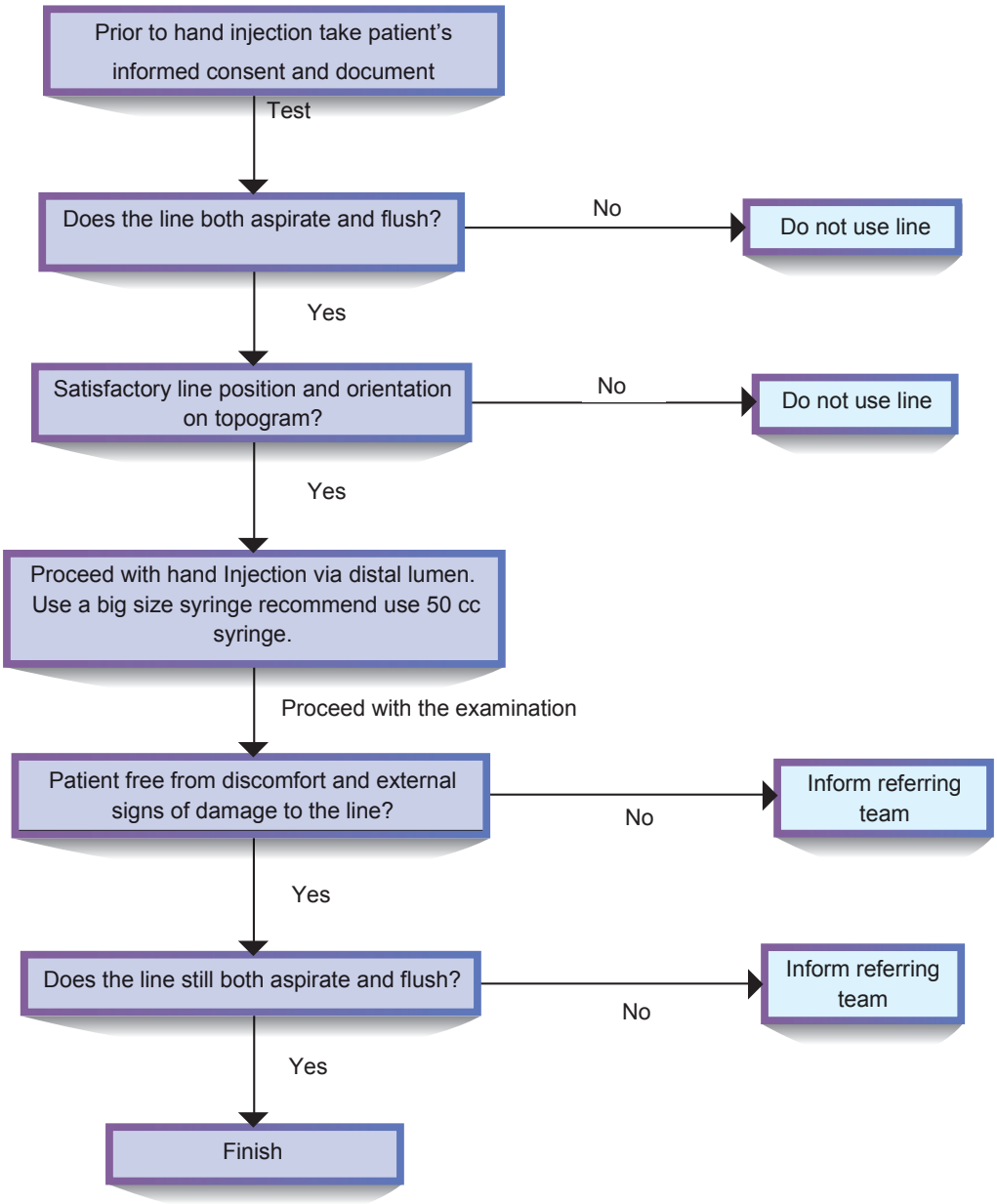
Appendix C

Flowchart for Intravenous Contrast Injection in CT via Central Venous Catheter by Power Injector



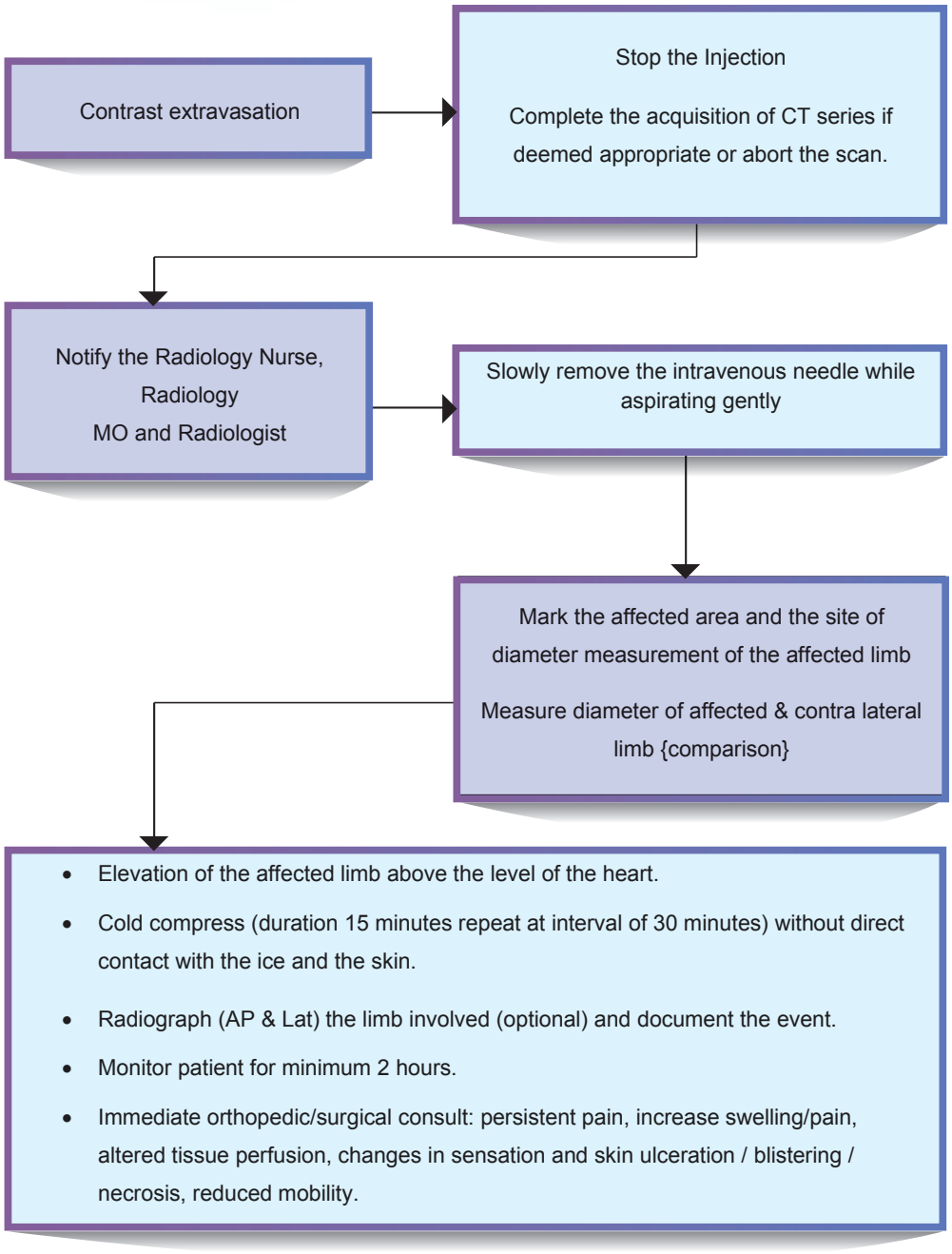
Appendix D

Flowchart for Intravenous Contrast Media Injection in CT via Central Venous Catheter by Hand Injection



Appendix E

In The Event of Extravasation (Flowchart)



EVOLUTION OF PATIENT

MILD

- Allow home (if outpatient)
- Provide leaflet
- Follow up next day via phone call/appointment & document

MODERATE

Outpatient:

- Refer to emergency department / primary team according to local context) & document.
- Follow up the next day & document

Inpatient:

- Inform primary team & document
- Follow up the next day & document

SEVERE

Outpatient:

- Refer to orthopedic / surgical team & document
- Inform primary team & document.
- Follow up the next day & document

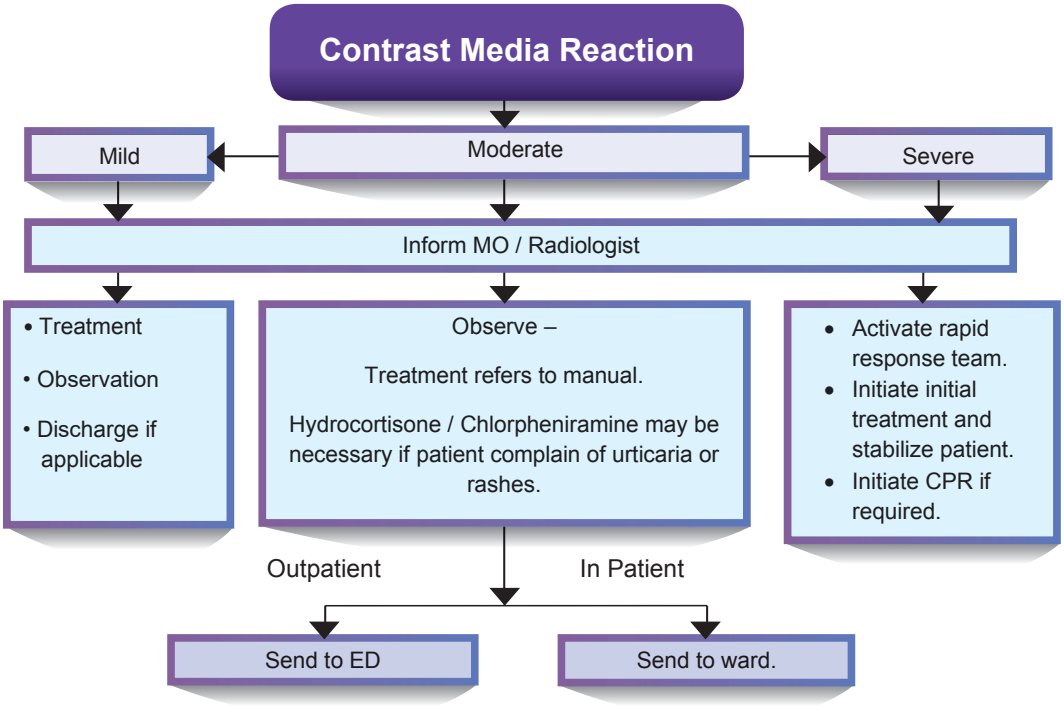
Inpatient:

- Refer to orthopedic / surgical team & document
- Inform primary team & document
- Follow up the next day & document

Appendix F (i)

Recording and Investigation of Significant Suspected Contrast Reaction (Flowchart)

Summarize workflow of Treatment of Reactions Adult and Pediatric : Please refer to management of anaphylactic iodinated contrast media reaction of appropriate manual e.g. [22]



Appendix F (ii)

Recording and Investigation of Significant Suspected Contrast Reaction (Flowchart)

Fill up the incident report and drug adverse forms.

Document in the radiology report & patient case notes

Pharmacy department should be informed.

↓

Investigation to be carried out by Radiology and Pharmacy Departments:
i.e. for crystallization, discoloration
(If so product complain is issued)

The contrast media bottle is isolated, and the contrast media batch identified for exchange in applicable cases.

Appendix G

1. Example of calculation: iodine gm and volume given in compromised renal function.
   *Need to use scientific calculator. Need to download The Calculator apps (for iPhone).

   A. Keep the ratio of iodine dose (in gram iodine) /absolute eGFR(ml/min) below 1.1
   Example: IV nonionic contrast media Iopamidol 300mg I /ml

   B. Keep the ratio of contrast volume (ml) / eGFR in ml/min per 1.73 m^2 below 3.0 for a contrast concentration of 350mg iodine/ml.
   Omnipaque (Iohexol) = 350 mg I/ml

   Method of Calculating Absolute eGFR:
   Step 1 : Body surface area (BSA) was calculated from the DuBois & DuBois Formula
   BSA (m^2) = 0.007184 × height (cm) $^{0.725}$ × weight (kg) $^{0.425}$.

   Step 2 : Conversion of BSA indexed GFR values (eGFR) to absolute eGFR values
   Absolute eGFR =
   (BSA indexed estimated GFR × Patients BSA) /1.73 m^2 = ml/min.

   - Conversion of absolute eGFR values to BSA indexed GFR values

   BSA Indexed GFR =
   (Absolute GFR × 1.73 m^2) / Patients BSA = ml/min per 1.73 m^2
   Reference {6}
   Keep the ratio of iodine dose (in gram Iodine) and absolute GFR (ml/min) below 1.1
   Example:
   1. eGFR : 111.2 (from renal profile result), height 160 cm, weight 60 kg
      Absolute GFR = $\frac{\text{eGFR x BSA}}{1.73}$
      BSA = 0.007184 x height (cm) $^{0.725}$ x weight (kg) $^{0.425}$
      = 0.007184 x 160 $^{0.725}$ x 60 $^{0.425}$ = 1.622
      Absolute GFR = $\frac{111.2 \times 1.622}{1.73}$ = 104.1 ml/min

   Step 3 : Contrast media dose : 100 ml Iopamidol (300 mg Iodine/ml)
   : 100ml x 300 mg = 30,000 mg= 30g
   Absolute GFR = 104.1

   Step 4 : Ratio of iodine dose (in gram Iodine) and absolute GFR = 30:104.1= 0.29 (√)

2. eGFR 30, height 160 cm, weight 60 kg
   Absolute GFR = $\frac{\text{EGFR X BSA}}{1.73}$
   BSA = 0.007184 X 160 $^{0.725}$ X 60 $^{0.425}$ = 1.622
   Absolute GFR = $\frac{30 \times 1.622}{1.73}$ = 28.1

Contrast media dose : 100 ml Iopamidol (300 mg Iodine/ml)
: 100ml x 300 mg = 30,000 mg= 30g

Absolute GFR = 28.1

Ratio of iodine dose (in gram Iodine) and absolute GFR = 30:28.1 = 1.1 (X)

Follow as closely as clinical circumstances permit. So adjust the dose in gram iodine:
Contrast media dose: 90ml x 300mg =27,000mg=27g
Ratio of iodine dose (in gram Iodine) and absolute GFR = 27:28.1 = 0.96 (√)

Keep the ratio of contrast volume and eGFR below 3.0 (for contrast concentration of 350mg iodine/ml) for example when using Omnipaque (Iohexol) = 350 mg I/ml

Contrast media volume: eGFR = 100: 111.2 = 0.89 (√)
Contrast media volume: eGFR = 100: 30 = 3.3 (X)
Follow as closely as clinical circumstances permit. So adjust the contrast media Volume.
Contrast media volume: eGFR = 85: 30 = 2.83 (√)

Note:

- Decision to use the concentration and volume according to the above calculation is up to the discretion of the in-charge radiologist after discussing with the referring doctor. As the concentration and volume might not be of diagnostic value.
- In certain clinical situations, the use of intravascular iodinated contrast medium of applicable concentration and volume may be necessary regardless of CI-AKI risk. Discussion with physician/ nephrologist is advised, informed high risk consent and document.

Appendix H

Refer National Radiology Services Operational Policy 2019 for consent form : *Keizinan - Prosedur Radiologi Yang Memerlukan Suntikan Media Kontras* (page 55-57) together with *Borang Permohonan Pemeriksaan Radiologi PER.SS-RA301 (Pind.1/2018)* (page 48-49)

Appendix I

Information Regarding Patient's Early Allergic Reaction to Intravascular Contrast Media

Please write or tick (√) at the appropriate boxes.

Type of exam : _____ Examination date: _____

Name of patient :_____

Hospital registration number : _____ Gender: _____ Age: _____

Weight : _____ kg Intravascular contrast media : Type: _____

Name of the contrast media: _____ Expiry date: _____

Volume: _____

Patient's sign & symptoms {1} :

Mild		Moderate		Severe	
Limited urticaria/pruritus		Diffuse urticaria/pruritus		Diffuse edema/facial edema with dyspnea	
Cutaneous edema		Diffuse erythema with stable vital signs		Diffuse erythema with hypotension	
Limited itchy/scratchy throat		Facial edema without dyspnea		Laryngeal edema with stridor and/or hypoxia	
Nasal congestion		Throat tightness or hoarseness without dyspnea		Wheezing/bronchospasm, significant hypoxia	
Sneezing/conjunctivitis /rhinorrhea		Wheezing/bronchospasm mild or no hypoxia		Anaphylactic shock (hypotension + tachycardia)	

Treatment given :

_____

_____

Does the patient require admission? ☐ Yes ☐ No

Does the patient require resuscitation? ☐ Yes ☐ No

Does the patient require intubation? ☐ Yes ☐ No

1) Keep the form within the record office, patient's BHT/ HIS.
2) Document the incident in patient's relevant imaging report.
3) Inform pharmacy of the patient's allergy to the specific intravascular contrast media so as patient may be given an allergy card as per local context.
4) Document that patient/guardian has been informed.

Appendix J

Patient Information Regarding Early Allergic Reaction to Intravascular Contrast Media
(Patient's Copy)

Please write or tick (√) at the appropriate boxes.

Type of exam : _____ Examination date : _____

Name of patient : _____

Hospital registration number : _____ Gender : _____ Age : _____

Weight : _____ kg Intravascular contrast media : Type : _____

Name of the contrast media : _____

Patient's sign & symptoms {1} :-

Mild		Moderate		Severe	
Limited urticaria/pruritus		Diffuse urticaria/pruritus		Diffuse edema/facial edema with dyspnea	
Cutaneous edema		Diffuse erythema with stable vital signs		Diffuse erythema with hypotension	
Limited itchy/scratchy throat		Facial edema without dyspnea		Laryngeal edema with stridor and/or hypoxia	
Nasal congestion		Throat tightness or hoarseness without dyspnea		Wheezing/bronchospasm , significant hypoxia	
Sneezing/conjunctivitis/ rhinorrhea		Wheezing/bronchospasm mild or no hypoxia		Anaphylactic shock (hypotension + tachycardia)	

Note:
Inform patients to bring this form and to inform doctor at the Radiology Department on the day of imaging procedure with IV contrast media.

Appendix K

Incidence of Contrast Media Extravasation at Radiology Department Hospital _____

Please write or tick (√) at the appropriate boxes.

Type of exam : _____ Examination date : _____

Name of patient : _____

Hospital registration number : _____ Gender : _____ Age : ____

Weight : _____ kg Cannula size : _____

Type of contrast/amount : _____ Contrast pre-warmed : Yes / No

Significant medical history : _____ (e.g. Diabetic, On Chemotherapy etc)

Vein status : ☐ Normal ☐ Abnormal (specify)

Site of cannula insertion/ no. of attempts : _____

Radiology personnel ☐ Others ☐

Flushing with : _____ (e.g. normal saline/water for injection/heparin saline)

Performed by : ☐ Radiology personnel ☐ Others

Informed consent : Including signs and symptoms of extravasation. ☐

Detection of extravasation : _____ (by Doctor/Radiographer/Nurse)

Patient signs/symptoms :

Pain		Swelling (Size.) ……		Discomfort		Erythema		Altered tissue perfusion. (e.g. reduced capillary filling, numbness)	

Action taken : Inform person in-charge ☐ Compress hot/cold ☐

After observation : Educate and discharge ☐ Refer and admit ☐

Follow up : Resolve with surgery ☐ Resolve without surgery ☐

Follow up by : _____

Comment : _____

Reporting personnel (radiologist or radiology medical officer)

_____

Name, Chop & Signature

Appendix L

Audit Tool CM Extravasation

Related to patient

Age of patient : _____

State of arterial vascularization, venous or lymphatic drainage: Normal or Poor

Any trophic disorder : _____

Any other predisposing factors e.g. diffuse atherosclerosis, Raynaud's disease, angiitis, DM, h/o of phlebitis, lymphatic infection, trophic disorder, previous radiotherapy or surgery on the treated limb, stigmas of repeated puncture.

Related to injection site

Injection site : _____

Duration of venous access < 24 hours ☐ > 24 hours ☐

Related to injection technique :-

Size of venous access device : _____

Rate of injection if power injection is used : _____

Use a power injector Yes No

Related to contrast media

Volume of contrast media given : < 50ml ☐ > 50ml ☐

Require referring department referral less than 2 hours of observation

- Yes No

Require referring department referral more than 2 hours oh observation

- Yes No

Does the patient require readmission after discharge?

- Yes No

Outcome of patient : ☐ Resolve without surgical intervention

☐ Required surgical intervention

Appendix M

Borang Informasi *Extravasation* Pesakit

Informasi pesakit jika berlaku pengeluaran kontras media dari salur darah setelah pemeriksaan pengimejan dengan suntikan intravena kontras media.

Kejadian ini berlaku 0.04% daripada semua suntikan intravena kontras media.

Sebab kejadian : contrast media telah terkeluar daripada salur darah vena yang disuntik kerana terdapat kebocoran pada salur darah vena tersebut semasa contrast media diberi.

Kebanyakan kejadian ini menyebabkan bengkak yang sedikit dan radangan kulit yang boleh sembuh serta tidak menimbulkan kesan atau akibat yang memudaratkan.
Walau bagaimanapun ada komplikasi boleh berlaku yang mungkin memerlukan rawatan segera.

Jika ada sebarang keraguan sila hubungi jururawat Jabatan Radiologi pada talian – ext: - semasa waktu bekerja normal.

Jika menghadapi tanda-tanda di bawah, sila mendapatkan rawatan segera di Jabatan Kecemasan Dan Trauma di hospital yang berdekatan dengan anda. Tanda – tanda berikut di sekitar kawasan suntikan adalah:

- Bengkak bertambah besar
- Bertambah sakit
- Jika terdapat perubahan warna kulit sama ada berubah menjadi pucat atau kebiru biruan
- Berasa kebas – kebas
- Jika ada terdapat gelembung air atau kulit melecet
- Kekurangan kekuatan otot/kekurangan jurang pergerakan sendi yang terlibat.

LAMPIRAN PERSEDIAAN PESAKIT : Jenis Pemeriksaan

A. Pemeriksaan CT/ MRI dengan intravena media kontras **KECUALI:**

i. ***CT SCAN ABDOMEN AND PELVIS***
ii. ***MRI OF THE BILIARY SYSTEM/ PANCREAS***

SEBELUM PEMERIKSAAN:

- Digalakkan makan makanan ringan.
- Pesakit yang tidak mempunyai *fluid restrictions* digalakkan minum sekurang kurangnya 500ml.
- Makan ubat seperti biasa kecuali jika ada arahan khas daripada doktor yang merawat.
- Bagi pesakit yang ada *fluid restrictions* sila ikut arahan doktor yang merawat.

SELEPAS PEMERIKSAAN:

- Bagi pesakit yang telah menjalani pemeriksaan CT scan, serta tidak mempunyai *fluid restrictions* digalakkan minum segelas air setiap jam untuk 8 jam.
- Bagi pesakit yang telah menjalani pemeriksaan MRI, digalakkan minum air kosong.
- Bagi pesakit yang ada *fluid restrictions* sila ikut arahan doktor yang merawat.

B. i. Pemeriksaan *CT scan abdomen and pelvis* dengan intravena kontras media
ii. Pesakit asthma/pernah mengalami alahan pada kontras media dalam kelas yang sama/mempunyai pelbagai alahan/pernah mengalami alahan yang serius yang memerlukan rawatan.

SEBELUM PEMERIKSAAN:

- Berpuasa 4 jam daripada makanan pejal dan minuman berkhasiat.
- Pengambilan air kosong dibenarkan.
- Bagi pesakit yang ada *fluid restrictions*, sila ikut arahan doktor yang merawat.
- Makan ubat seperti biasa kecuali jika ada arahan khas daripada doktor yang merawat. Bagi pesakit kencing manis disarankan untuk mengikut arahan doktor merawat tentang penghentian ubat kencing manis yang tertentu pada hari pemeriksaan.

SELEPAS PEMERIKSAAN:

- Bagi pesakit yang telah menjalani pemeriksaan CT scan, serta tidak mempunyai *fluid restrictions* digalakkan minum segelas air setiap jam untuk 8 jam.
- Bagi pesakit yang telah menjalani pemeriksaan MRI, digalakkan minum air kosong.
- Bagi pesakit yang ada *fluid restrictions*, sila ikut arahan doktor yang merawat.

iii. ***MRI OF THE HEPATOBILIARY SYSTEM/ PANCREAS***

SEBELUM PEMERIKSAAN:

- Berpuasa 4 jam daripada makanan pejal dan minuman.
- Makan ubat seperti biasa kecuali jika ada arahan khas daripada doktor yang merawat. Bagi pesakit kencing manis disarankan untuk mengikut arahan doktor merawat tentang penghentian ubat kencing manis yang tertentu pada hari pemeriksaan.

SELEPAS PEMERIKSAAN:

- Pesakit yang tidak mempunyai *fluid restrictions* digalakkan minum air kosong
- Bagi pesakit yang ada *fluid restrictions*, sila ikut arahan doktor yang merawat

C. i. Pemeriksaan CT/ MRI dengan sedasi.
ii. Prosedur Radiologi diagnostik atau *interventional* dengan *intravascular* media kontras.

Makluman persediaan

- Berpuasa daripada makanan pejal **6 jam** sebelum pemeriksaan.
- Berpuasa daripada minuman berkhasiat **4 jam** sebelum pemeriksaan
- Berpuasa daripada air kosong **2 jam** sebelum pemeriksaan.
- Bagi pesakit kencing manis disarankan untuk mengikut arahan doktor merawat tentang penghentian ubat kencing manis yang tertentu pada hari pemeriksaan.

NB : Bagi kes pemeriksaan radiologi yang dijalankan dengan *general anesthesia* persediaan pesakit termasuk regimen berpuasa adalah mengikut arahan pakar bius.

LAMPIRAN MAKLUMAT TAMBAHAN UNTUK STRATIFIKASI PESAKIT YANG MENJALANI PROSEDUR RADIOLOGI YANG MEMERLUKAN SUNTIKAN MEDIA KONTRAS

	Perkara	Cadangan tindakan jika berkenaan
a	Sejarah reaksi terhadap media kontras	Pra-medikasi steroid. *Tab Prednisolone 40mg 12 jam dan 2 jam sebelum prosedur* (Dos dewasa yang dinyatakan, Dos kanak-kanak perlu dikira mengikut berat badan unggul).
b	Sejarah alahan terhadap ubat-ubatan /makanan	
c	Sakit asma*/hay fever/atopy*/alahan resdung/*rhinitis*	
d	Penyakit tiroid	Pesakit hendaklah diperiksa oleh doktor yang merujuk untuk hipertiroid dan mengoptimakan keadaan pesakit jika hipertiroid sebelum IV media kontras iodin.
e	Penyakit *multiple myeloma with renal impairment*	Untuk pesakit *multiple myeloma* yang mempunyai fungsi buah pinggang tidak normal, dinasihatkan pesakit diperiksa oleh pakar perubatan/ pakar nefrologi dan mengoptimakan keadaan pesakit sebelum IV media kontras iodin.
f	Penyakit ginjal	Doktor yang merawat perlu mengoptimakan keadaan pesakit.
g	Penyakit jantung	
h	Mengambil ubat-ubatan kencing manis (metformin) atau ubatan nefrotoksik.	Doktor yang merawat hendaklah menentukan keperluan pengambilan ubatan berkenaan. **Bagi metformin,** sila rujuk “SOP contrast media Table 6.5.1”

NB : Sila bincang dengan pakar radiologi sekiranya perlu.

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LIST OF ABBREVIATION

ACR	American College of Radiology
AKI	Acute Kidney Injury
AP	Anteriorposterior
BSA	Body Surface Area
CA	Carcinoma
CA-AKI	Contrast-Associated Acute Kidney Injury
CI-AKI	Contrast-Induced Acute Kidney Injury
CIN	Contrast-Induced Nephropathy
CKD	Chronic Kidney Disease
CM	Contrast Media
COPD	Chronic Obstructive Pulmonary Disease
CPR	Cardiopulmonary resuscitation
CT	Computed Tomography
CTA	Computed Tomography Angiography
CVC	Central Venous Catheter
DM	Diabetic Mellitus
ED	Emergency Department
eGFR	Estimated Glomerular Filtration Rate
ESUR	European Society of Urogenital Radiology
FAQ	Frequently Asked Questions
FDA	Food and Drug Administration
GBCA	Gadolinium Based Contrast Agent
GD-based	Gadolinium-based
GD-CM	Gadolinium-Contrast Media
GFR	Glomerular Filtration Rate
H/O	History of

ICU	Intensive Care Unit
IV	Intra venous
IVU	Intravenous Urography
KDIGO	Kidney Disease: Improving Global Outcomes
KPI	Key Performance Indicator
kV	Kilo Volt
LMP	Last Menstrual Period
MHRA	Medicines and Healthcare Products Regulatory Agency
MO	Medical Officer
MOH	Ministry of Health
MR	Magnetic Resonance
MRI	Magnetic Resonance Imaging
NIA	National Imaging Associates
NSF	Nephrogenic Systemic Fibrosis
OGLD	Oral Glucose Lowering Drugs
PC-AKI	Post-Contrast Acute Kidney Injury
Rx	Treatment
SOP	Standard Operating Procedures
SVC	Superior Vena Cava

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ISBN 978-967-26348-3-6