

CHAPTER 1

General Principles: How to Interpret Radiographs

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Emergency medicine often brings together critically ill patients with inexperienced junior doctors – a dangerous combination with potentially serious consequences. The huge volume of information necessary to manage these patients adequately is overwhelming, as virtually any condition can present itself. The difficulties are compounded because radiographs are requested for many patients. These radiographs may be interpreted by relatively inexperienced, and often tired, personnel who have little training in how to evaluate them.

Radiographic projections

Site	View	Comment
Finger	Anteroposterior and lateral	
Hand	Anteroposterior and oblique	
Wrist	Anteroposterior and lateral	Four views for suspected scaphoid fractures
Elbow	Anteroposterior and lateral	Additional views if fat pad present
Shoulder	Anteroposterior and Y view	
Pelvis and sacrum	Anteroposterior only	Coccyx views rarely indicated
Hip	Anteroposterior and oblique	Anteroposterior of both hips and oblique or lateral of injured hip
Knee	Anteroposterior and lateral	Lateral is done with a horizontal beam
Ankle	Anteroposterior and lateral	Anteroposterior mortice view for trauma
Feet and toes	Anteroposterior and oblique	
Cervical spine	Anteroposterior, lateral, and peg	Lateral must show C7/T1 (otherwise computed tomography)
Thoracic spine and lumbar spine	Anteroposterior and lateral	
Chest	Posteroanterior erect or anteroposterior	Also anteroposterior supine (trauma)
Abdomen	Anteroposterior supine	Erect anteroposterior chest radiograph helpful
Head	Computed tomography scan	Plain skull radiographs rarely indicated
Face	Occipitomenal and occipitomenal 30°	Posteroanterior or posteroanterior 20°
Mandible	Anteroposterior view and orthopantomograph	Oblique view if orthopantomograph not available
Foreign bodies	Anteroposterior and lateral or tangential	Metal marker at entry site. Consider ultrasonography first or computed tomography

Rules of two

The rules of two are a simple set of guidelines. Most rules should be obvious and some relate to specific problems, but they are useful general principles that help to avoid errors in interpretation of radiographs and management of patients.

Rules of two

10 simple rules to follow

- 1 Two views: one view is one view too few
- 2 Two joints: image the joint above and below a long bone
- 3 Two sides: compare the other side (difficult cases only)
- 4 Two abnormalities: look for a second abnormality
- 5 Two occasions: compare current films with old films (especially for chest radiographs)
- 6 Two visits: repeat the film after a procedure or after an interval
- 7 Two opinions: ask colleague for opinion or use red dot system
- 8 Two records: write down clinical and radiographic findings
- 9 Two specialists: also get a formal radiological report
- 10 Two examinations: do not forget other tests such as ultrasonography, computed tomography, magnetic resonance imaging, and isotope bone scanning

1 Two views

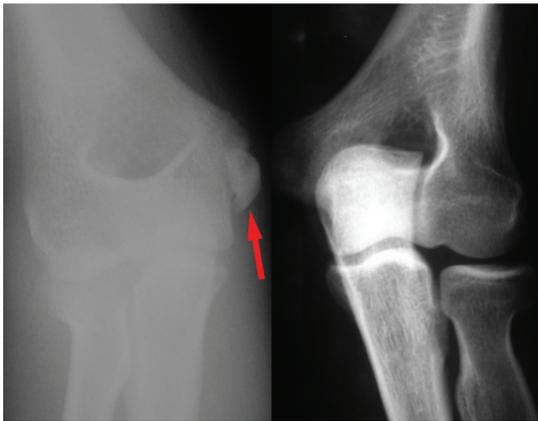
Preferably, the two views should be perpendicular to each other. This rule applies to virtually all radiographs obtained, except for those of the chest, abdomen, and pelvis. Rarely, the abnormality is not visible at all or is subtle on the first view.

2 Two joints

Image the joint above and below a long bone. This particularly relates to mid-shaft injuries of the forearm (radius and ulna) and lower leg (tibia and fibula). Sometimes subtle injuries may be present in the joint above or below the obvious fracture.

3 Two sides

Rarely, the abnormality may be difficult to detect, and comparison with the other side can be helpful, especially in children. Always get a second opinion before requesting another radiograph because it means exposing the patient to additional radiation (an especially important consideration with children).



Rule 3 Anteroposterior view of right elbow (left) and anteroposterior view of left elbow (right). The right elbow has a non-united, avulsed, right medial epicondyle (arrow). The injury is obvious when compared with the normal left elbow with fused epiphyses.



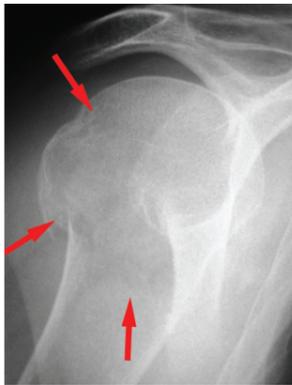
Rule 1 Anteroposterior (left) and lateral view of right ankle (right). The anteroposterior view was considered normal. The lateral view shows a displaced oblique fibula fracture (arrows).



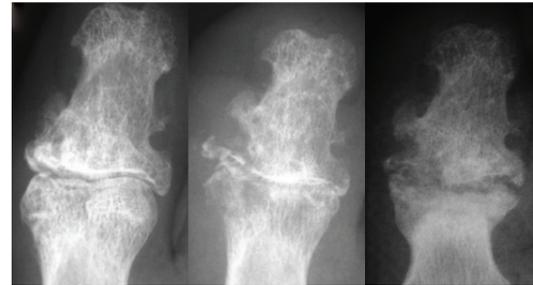
Rule 2 Anteroposterior view of right leg (left), lateral view of right knee (middle), and anteroposterior view of right knee (right). Shows a Salter-Harris type II injury – proximal tibial metaphysis is fractured, with separation and displacement of the epiphyseal growth plate and undisplaced fibula fracture (arrowhead).

4 Two abnormalities

Do not stop looking after you find one abnormality. An underlying predisposing cause may be the reason for the fracture (pathological fracture), or an unrelated incidental finding (such as a “bone island”) might be present.



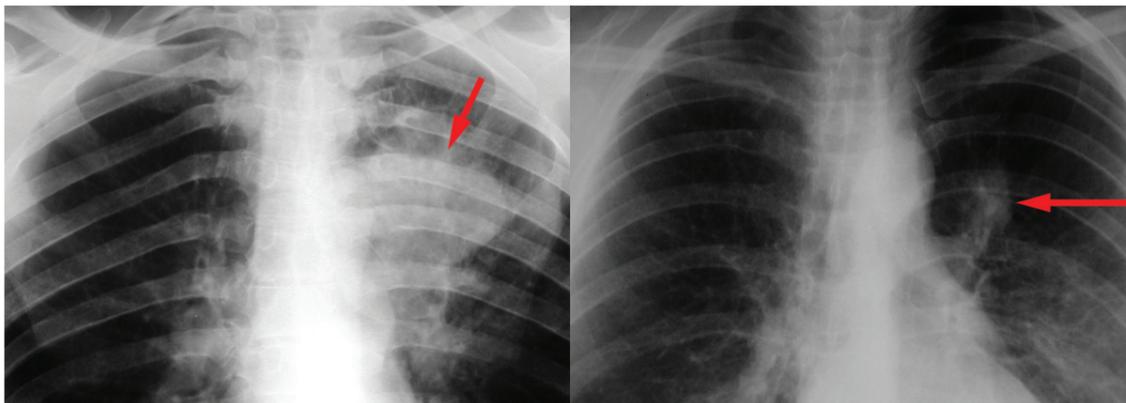
Rule 4 Anteroposterior view of right humerus shows pathological fracture through lytic metastasis (arrow).



Rule 5 Septic arthritis in big toe. Initial film (left) was considered normal, but the loss of the joint space and the rapid progression confirms the diagnosis. The radiograph in the middle was taken when the diagnosis was made. The radiograph on the left was taken two weeks before, and the radiograph on the right was taken two weeks after the diagnosis.

5 Two occasions

If old films are available, always take the opportunity to look at them. This is particularly relevant in chest radiographs, because previous films will tell you if the latest radiograph shows an old or new finding. Similarly, if there is a bony abnormality, in particular if osteomyelitis or a septic arthritis is suspected, old films are essential for early diagnosis.



Rule 5 Posteroanterior chest radiograph (magnified view). Shows a primary bronchogenic carcinoma. Comparison with the chest radiograph of the same patient that was taken a year earlier (right) shows that the left hilar mass has enlarged over a year. The posteroanterior chest radiograph on the right (magnified view) was thought to be normal, but in retrospect, the tumour was visible (arrow).

6 Two visits

Always bring the patient back for a repeat set of radiographs after a procedure – especially after surgery, setting a fracture in plaster, reducing a dislocation, or removing a foreign body.

Sometimes the patient should come back for a repeat film after a set period of time to see whether the abnormality has resolved, got worse, or not changed. Classic scenarios in which this would be appropriate include a suspected scaphoid fracture or when abnormalities on chest radiographs are seen and an old film is not available for comparison.



Rule 6 Lateral view of elbow in a plaster of Paris. Mid-shaft ulna is fractured (arrowhead), but the dislocated radial head had not been reduced (arrow).

7 Two opinions

Wherever possible, get a second opinion or show the radiograph to someone else. This is especially important if you are unsure about the radiograph. If the red dot system is used in your hospital, then this can be your first opinion.

The red dot system was introduced to help emergency department doctors. It is a voluntary system where the radiographer who took the radiograph gives his or her opinion as to whether the film is abnormal by placing a red dot next to the abnormality. It was initially, and in most hospitals still is, used for the peripheral skeleton only – that is, limb injuries. The red dot system helps to reduce errors and improve accuracy.

Radiographers are usually extremely experienced at taking films, looking at and interpreting them. Always ask the radiographer who took the film for their opinion first, especially if there is a red dot and you cannot find an abnormality.

8 Two records

Apart from recording the history and results of the examination, always record the findings of the radiograph. It is easy to look at the film and to forget to write down the findings. Films get lost, and your written record may be the only record.

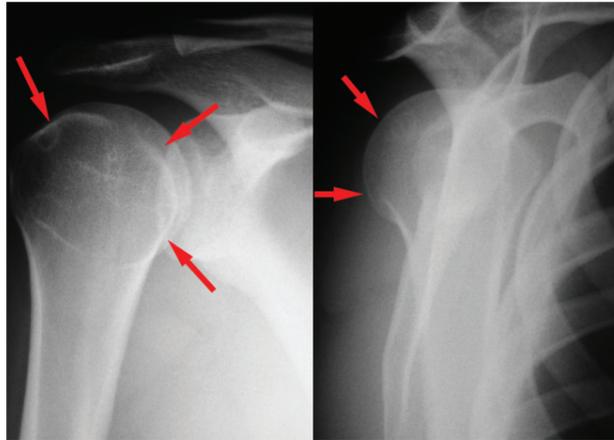
9 Two specialists

All films should be seen and reported formally by a radiologist. This is particularly important for films that are at first thought to be normal because the patient is usually discharged and may not be seen by anyone else.

10 Two examinations

Sometimes, if the plain radiograph is normal, the symptoms may warrant further investigation. Studies have shown that if a scaphoid fracture is suspected and the scaphoid series of films are normal, the patient should have a magnetic resonance image scan when possible, rather than putting the patient in a splint or plaster and waiting 10–14 days before taking another set of films, which is “accepted normal management.”

In addition, several abnormalities detected on plain radiographs warrant further imaging. If a fracture extends to the major joints (for example, acetabular and tibial plateau fractures), a computed tomography scan of the joint should be done routinely to evaluate the extent of joint involvement and to exclude loose fragments.



Rule 7 Anteroposterior view (left) and Y view (right) of right shoulder shows subtle posterior dislocation of the shoulder (arrow). Initially, these radiographs were interpreted as normal. The patient was then recalled to the emergency department by the radiologist for clinical review.

The more interesting a radiograph is, the more likely it will be stolen or lost

The rules of two relate to what films to request, how to get help, and what to do next. This is an extension of the seventh commandment in Touquet's ten commandments of emergency radiology (see page 9)



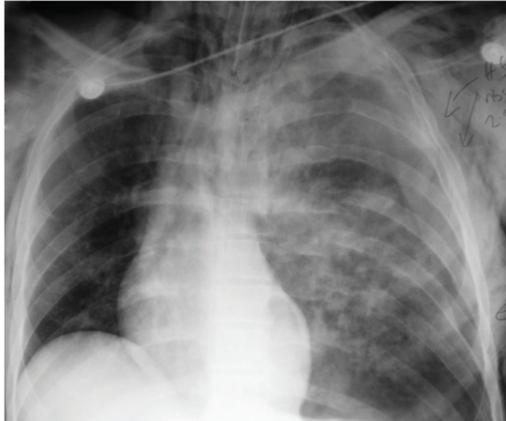
Rule 10 Anteroposterior view of scaphoid (left) and T1 weighted coronal magnetic resonance image (right) showing scaphoid fracture. Scaphoid series normal, but magnetic resonance image shows a fracture (arrow).

Ten commandments

Touquet's ten commandments are a simple set of guidelines to protect staff and hospitals from the inevitable mistakes that inexperienced doctors will make. Unfortunately, the commandments are often ignored. Many of the ten commandments are incorporated in the rules of two.

Command 1: treat the patient not the radiograph

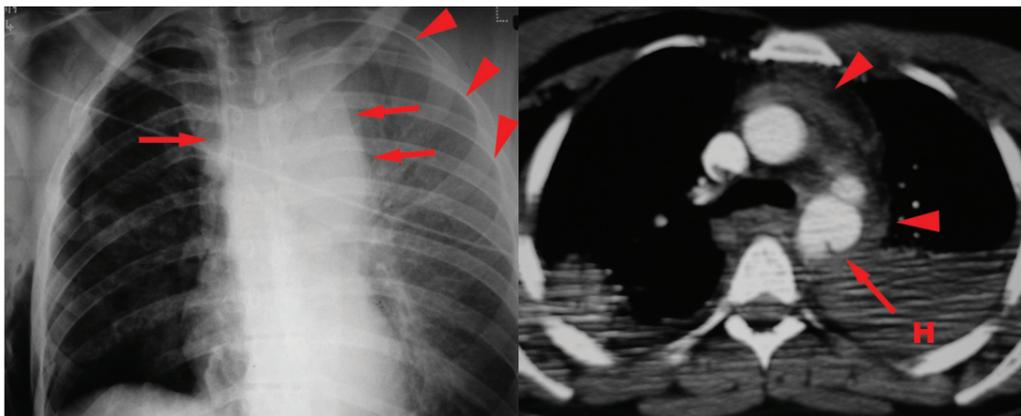
Certain conditions or injuries should be treated on the basis of the clinical findings initially, especially if the injury is life threatening (such as a tension pneumothorax). With other injuries, delaying initial treatment to obtain a radiograph is unnecessary (for example, a dislocated ankle). The delay may be either life threatening, or have long term sequelae. In addition, a finding on the radiograph may be an incidental finding (the fourth rule in the rules of two).



Command 1 Left tension haemopneumothorax. The patient should have been treated with a chest drain insertion before the chest radiograph was taken.

Command 2: take a history and examine the patient before requesting a radiograph

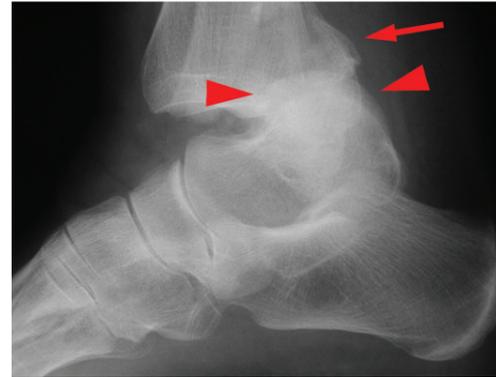
A thorough clinical history and examination enables the mechanism of injury to be established, and the appropriate radiographs can then be requested. Knowledge of the mechanism of injury can often help to determine the likely pattern of injuries.



Command 2 Chest radiograph taken after a road crash (left) showing a widened mediastinum (arrow), and a haemothorax (arrowhead). A traumatic aortic injury was suspected and a computed tomogram was requested. The computed tomography image (right) confirms traumatic aortic injury (arrow) with associated mediastinal haematoma (arrowhead) and a large left haemothorax (H).

Touquet's ten commandments of emergency radiology

- Command 1: treat the patient not the radiograph
- Command 2: take a history and examine the patient before requesting a radiograph
- Command 3: request a radiograph only when necessary
- Command 4: never look at the radiograph without seeing the patient and never see the patient without reviewing the radiograph
- Command 5: look at the radiograph, the whole radiograph and the radiograph as a whole in appropriate settings
- Command 6: re-examine the patient when incongruity exists between the radiograph and the expected findings
- Command 7: remember the rules of two
- Command 8: take radiographs before and after procedures
- Command 9: if a radiograph does not look quite right, ask and listen (the seventh rule of the rules of two)
- Command 10: ensure you are protected by failsafe mechanisms



Command 1 Dislocated left ankle. The ankle should have been reduced without the radiograph.

Tension pneumothorax, dislocated joints (for example, hip or ankle), and a pulled elbow in a toddler are examples of conditions where treatment should be started on the basis of clinical findings

Command 3: request a radiograph only when necessary

Many requested investigations do not alter the patient's management, and in some cases they may be misleading. In head injuries, there is virtually no indication for performing a skull radiograph. Most patients who have sustained a substantial head injury should have a computed tomography scan. A safe approach to head injuries is always to scan it.

Command 4: never look at the radiograph without seeing the patient and never see the patient without reviewing the radiograph

Look at the radiograph properly, not be biased, and use a systematic approach. Always get the clinical history before giving an opinion. Then you will often pick up abnormalities that you may otherwise have missed. Never rely on someone else's opinion or report on radiographs if you have not seen the radiographs yourself. This is particularly relevant when patients are handed over at the end of a shift or when patients are transferred from elsewhere.

Command 5: look at the radiograph, the whole radiograph, and the radiograph as a whole in appropriate settings

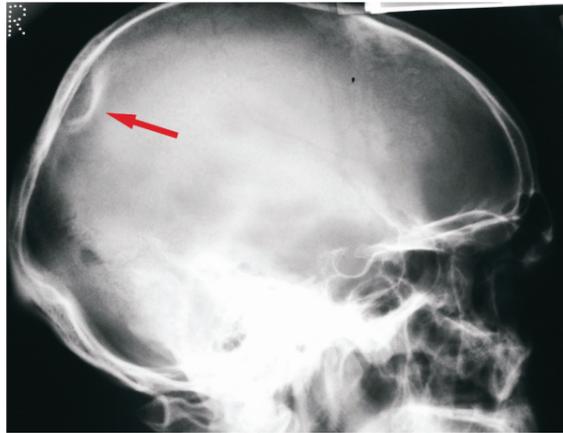
In a pressured environment such as an emergency department, it is easy to rush and make mistakes. Interpreting radiographs too quickly inside a badly lit, noisy room with many distractions is a recipe for disaster. Interpretation of radiographs should be done in a calm manner in a quiet, well lit room using a viewing box or monitor. A common problem is that the person assessing the radiograph will focus immediately on expected abnormalities.

Even knowing the clinical history, try to ignore it at first and use a systematic approach. It is critical though that you always get the clinical history before giving your *final* opinion or report, because you must try to interpret the radiological findings in the context of the clinical presentation and answer the question.

Command 6: re-examine the patient when an incongruity exists between the radiograph and the expected findings

Review the radiographic findings in conjunction with the patient's history and your clinical findings. If the radiograph does not fit, re-view the history and clinical findings or ask for help. Many cases require further imaging – for example, request a magnetic resonance scan or an isotope bone scan in an elderly patient with a suspected fracture of the neck of femur, even if the initial plain radiographs seem normal.

Trauma to the coccyx, most clinically obvious nose fractures, head injuries (request a computed tomography scan), and simple rib fractures are examples of when radiographs are not necessary

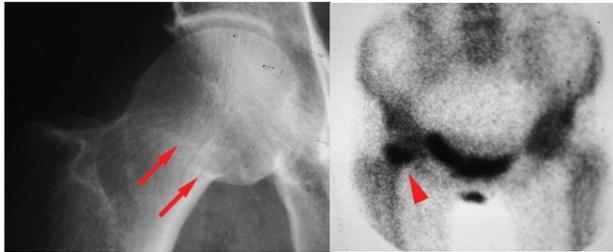


Command 3 Skull radiographs are not usually needed when dealing with head injuries. Important findings are generally subtle and often missed. This patient has a depressed skull fracture (arrow).



Command 3 Computed tomography image of head shows large left extradural haematoma (arrow) and subtle large right subdural haematoma (arrowhead).

In review clinics, radiographs are often lost or not available, but you must review previous radiographs. As a minimum, get the radiologist's report or repeat the films



Command 6 Anteroposterior view of right hip showing subtle fracture of neck of femur (arrow), which was missed initially (left) and later confirmed on isotope bone scan as a fracture (arrowhead).



Command 6 Anteroposterior and lateral views of the elbow showing fracture-dislocation of capitellum. Patient clinically very tender with limited range of movement – review shows fracture and dislocation of capitellum (arrow).

Command 7: remember the rules of two

The original commandments included two views, two joints, two sides, and two occasions only (see the first, second, third, and fifth of the rules of two).

Command 8: take radiographs before and after procedures

See the sixth of the rules of two.

Command 9: if a radiograph does not look quite right, ask and listen

See the seventh of the rules of two.

Command 10: ensure you are protected by failsafe mechanisms

See the eighth and ninth of the rules of two. Abnormalities will be missed by all grades of staff and in all specialties. A report from a radiologist as well as personnel from the emergency staff, however, will minimise the effect of these errors on the patient and in the eyes of the law. Reports should be timely and accurate, and these failsafe mechanisms should be audited regularly. To miss an injury radiologically may not be negligent, but not to have a system in place to provide for this eventuality is negligent.

ABCs systematic assessment

The rules of two and the ten commandments are helpful guidelines for who, what, how, and when to radiograph and how to minimise the chances and consequences of errors.

The ABCs systematic assessment shows how to interpret radiographs. It is particularly helpful for junior doctors who have had little or no training on how to look at radiographs. This approach will help to familiarise them with the normal radiographs and minimise interpretive errors.

The ABCs systematic assessment is different for each type of body system. The ABCs for the peripheral skeleton are the same, but it is worth changing the order slightly to look for specific signs, in particular a fat pad sign in the elbow or a fat-fluid level (lipohaemarthrosis) in the knee. Both of these signs are easy to detect and should alert you immediately to the presence of a probable fracture. Hence in the elbow and knee start by looking at soft tissues.

ABCs systematic assessment (the A also stands for anatomy in all systems)

Peripheral and axial skeleton

- Alignment
- Bones
- Cartilage and joints
- Soft tissues and foreign bodies

Chest

- Adequacy, all lines and tubes and airways – follow trachea and bronchi
- Breathing – Compare and contrast left and right lungs
- Circulation – Review heart, hila, and pulmonary vasculature
- Diaphragm
- Edges – Trace the pleura
- Skeleton – Edge the bones, review soft tissues, and seek foreign bodies

Abdomen

- Air – Search for free intraperitoneal air and abnormal air
- Bowel gas pattern
- Calcification
- Densities – For example, look for foreign bodies, or tablets
- Edges – For example, hernial orifices, or lung bases
- Fat planes – Relating to psoas, kidneys, and bladder
- Soft tissues and skeleton

Head (computed tomography scan)

- Airspaces
- Brains and bones
- Cerebrospinal fluid spaces
- Dural spaces
- Eyes
- Face
- Soft tissues

Face

- Alignment – Trace McGrigor's and Campbell's lines
- Bones – Consider LeFort's classification
- Cartilage – Delineate zygomaticofrontal suture and temporomandibular joints
- Densities – Search for foreign bodies, glass, metal
- Soft tissues and sinuses – For example, frontal, ethmoid, and maxillary

Cervical spine (thoracic spine and lumbar spine)

- Adequacy, all lines and tubes, and airway
- Alignment
- Bones
- Cartilage – Check disc spaces and joints
- Soft tissues (prevertebral, paravertebral, and psoas)



Lateral view of elbow – Look for fat pad sign first. An anterior (arrow) and posterior (arrowhead) fat pad sign indicate a probable fracture.



Horizontal beam lateral view of knee shows a lipohaemarthrosis (arrow). The fat (black) floats on the blood (white). This indicates a fracture (arrowhead), which in retrospect is visible.

KEY POINTS

- Request the correct radiographic examination
- Knowledge of anatomy is essential for evaluation of a radiograph
- Fundamental principles help reduce errors
- Remember the rules of two and the ten commandments
- Use a systematic approach to evaluate radiographs (ABCs)

Further reading

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