Emergency Bulletin
Hong Kong College of Emergency Medicine

Ballistic trauma – Gun Shot injury

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A 24- years-old gentleman suffered from right knee penetrating injury by a firearm. He was brought to the Accident and Emergency Department under police escort.

On arrival, his vitals were stable.
- Blood pressure: 125/50 mmHg, pulse 91 beats per minute
- SpO2: 99% on room air with normal respiratory rate
- Glasgow coma scale: 15/15

What is the approach to the patient?
The patient suffered from a penetrating injury of right knee. We should proceed to primary survey to look for any life-threatening injuries.

After primary survey and initial stabilization, we should proceed to secondary survey, obtain further history and evaluate the injured extremity.

Compare	• Compare both side
Look	• Colour and perfusion
	• Swelling and deformity
	• Wound or bruise
Feel	• Local tenderness
	• Test for sensation
	• Check distal pulse or use Doppler ultrasound to assess arterial blood flow • Capillary refill
Move	• Active and passive range of movement
	• Limb power

Table 1: Evaluation of injured extremity

The initial management of penetrating extremity injury include:
- Haemorrhage control
- Pain control
- Tetanus prophylaxis and wound management
- Consideration of antibiotics

Obtain an x-ray if we suspect an open fracture, joint penetration or any radio-opaque foreign body.

Progress of patient

On secondary survey, there is a circular wound measured 1.5cm x 1.5cm located at anterior medial distal femur with mild oozing. (Figure 1)

Figure 1: Clinical photo: the wound is located 5cm medial to the medial border of right patella and 4cm above medial joint line.

X-ray of right knee showed a 10mm x 15mm radio-opaque foreign body over medial femoral condyle. (Figure 2) There was no obvious fracture seen.

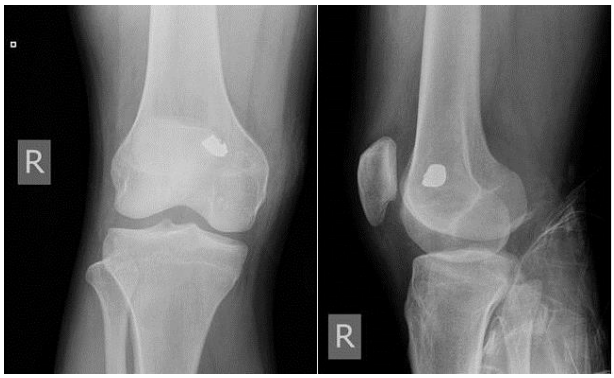

Figure 2: X-ray of right knee

Gunshot wound (GSW)
Gunshot injury is a rare form of a penetrating injury in Hong Kong. Before talking about the management of gunshot wound, we need to have some basic knowledge. We will briefly describe rifling, caliber and structure of a bullet.

Rifling
Rifling is the helical groove pattern that is machined into the internal (bore) surface of a gun's barrel. (Figure 3) Rifling imparts a rotational spin on the bullet as it travels down the barrel which stabilizes its flight through the air, preventing it from tumbling. (Figure 3)

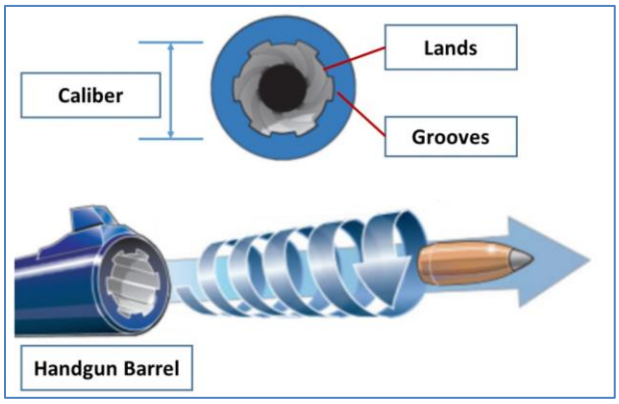

Figure 3: Rifling in the gun's barrel and rotational spin on the bullet

However, the spin does not stabilize the bullet in the body. Once a bullet enters the body, it starts to yaw. Yawing of a bullet is the deviation of a bullet in its longitudinal axis from the straight line of flight. If the wound path is long enough, the bullet may flip 180 degrees and travel base forward. (Figure 4)


Figure 4: Yawing of bullet

Caliber and barrel length
Caliber is the approximate internal diameter of the gun barrel and barrel length is sometimes measured in terms of number of calibers.

A longer barrel improves stability, since it spins the bullet for longer. It also increases the speed of the bullet, since the gas pressure accelerates the bullet for a longer period.

Bullet
A bullet consists of three parts: The primer, the propellant and the Projectile (Bullet). The primer is located at the base of the cartridge. When struck by the firing pin, it ignites the propellant. The bullet then rockets out of the barrel of the gun and does most of the damage. (Figure 5)

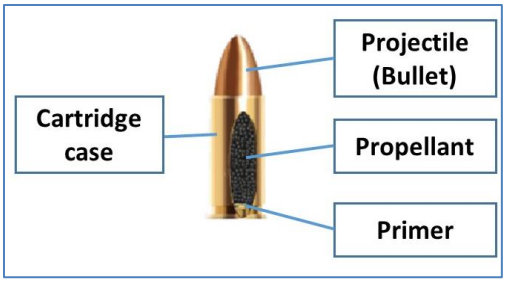

Figure 5: Structure of a bullet

How to distinguish the entrance and the exit wound?
Typically, entrance wounds are round to oval in configuration with a reddish, reddish-brown margin of abraded skin (the abrasion ring).[1] (Figure 6)

Exit wounds are typically larger and more irregular than entrance wounds and do not possess an abrasion ring. Exit wounds can be stellate, slit-like, crescent, circular, or completely irregular. (Figure 7)

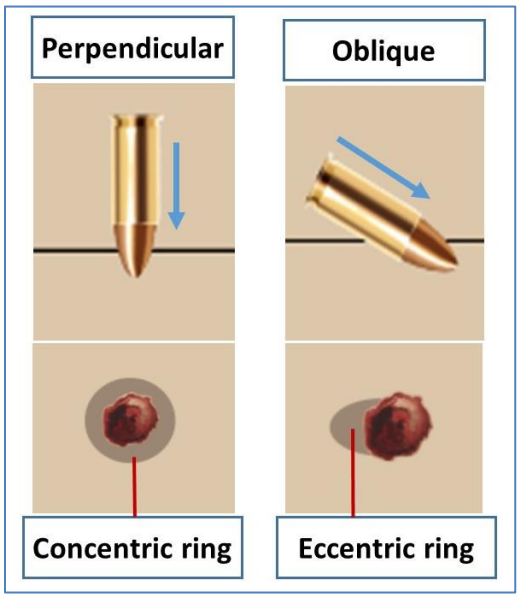

Figure 6: Abrasion ring of Entry wound

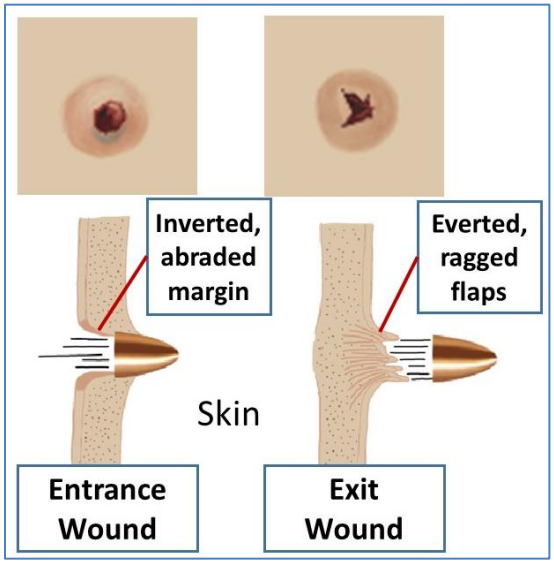

Figure 7: Entrance wound and exit wound

Summary of difference between entrance and exit wound are as follow: (Table 2)

	Entrance	Exit
Size	Smaller	Larger
Shape	Round / oval	Irregular / torn
Clothing	Clothes are turned into the wound	Clothes may be turned out
Bleeding	Slight	Profuse
Edges	Inverted	Everted
Abrasion ring	Presence	Absence
Lead ring	Presence (chemical or radiological examination)	Absence (chemical or radiological examination)
Tattooing effect	Presence	Absence

Table 2: Difference between entrance and exit wound

Progress of patient

The patient was admitted to the orthopaedic ward. Computed tomography of right knee was performed. (Figure 8) It showed a radio-opaque foreign body embedded in right distal femur with associated fracture.

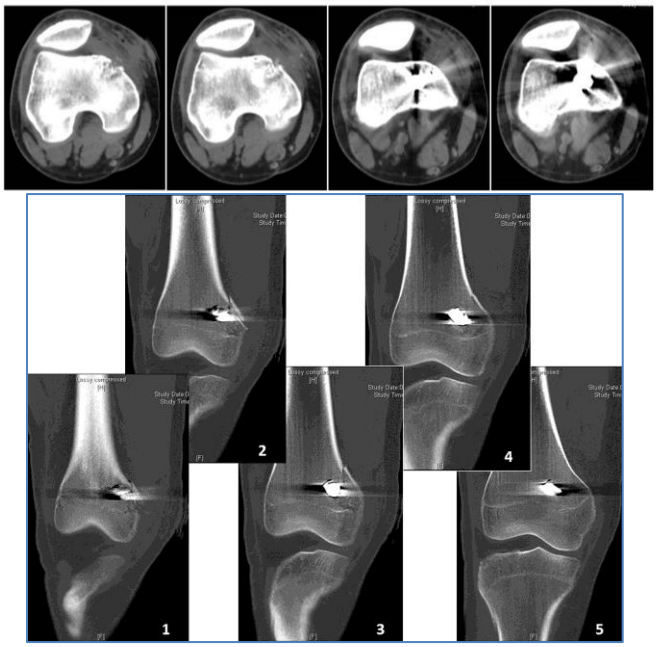

Figure 8: CT scan of right knee

What is the effect of GSW on extremity tissue?

The amount of damage inflicted on tissue depends on the amount of kinetic energy possessed by the bullet when it strikes the body and the amount possessed when, and if, it exits the body. The Kinetic energy is equal to

$$\text{Kinetic Energy} = (\text{Mass of bullet} \times \text{Velocity}^2)/2$$

Therefore, with increasing velocity, energy transfer increases exponentially. Other factors

like deforming, yawing, fragmentation and tissue characteristics also matter.

In general, the structures in the extremities are more tolerant of gunshot injuries when compared with the central nervous system, heart and great vessels.

Skin and muscle
These tissues are relatively elastic and therefore tolerate the temporary stretching effect of cavitation relatively well with limited tissue necrosis. Functionally, injuries to these tissues are also well tolerated.

Neurovascular structures
Nerves and vessels are often relatively fixed anatomically and therefore are vulnerable to the temporary distorting effect of cavitation. They can remain macroscopically intact away from the permanent cavity; however, intimal damage in vessels and axonal damage in nerves can result in functional failure even it is located some distance from the path of the bullet.[2,3]

Bone
The strength of this tissue means that it exerts a significant retarding effect on projectiles that strike it. This results in considerable energy transfer, often with extensive fragmentation of both bone and bullet.[4,5]

Please outline the management plan for the patient.
Damage control principle is adapted when managing gunshot injury.[6] It emphasizes on preventing the lethal triad of trauma (acidosis, hypothermia and coagulopathy) and minimizing additional stress on the physiology of the severely injured person.[7]

Haemorrhage control
Haemorrhage control can usually be achieved by direct pressure dressing and, if necessary a proximal haemostatic arterial tourniquet.

Infection and tetanus
Although there is a common misconception that the heat generated by the firing of a bullet sterilizes the bullet, many gunshot wounds are prone to bacterial and tetanus infection and require antibiotics.

As the bullet passes through the tissue, the vacuum that is created pulls foreign debris e.g. dirt, bacteria and clothing particles, into the wound leading to contamination.

Antibiotics and anti-tetanus and/or tetanus immunoglobulin should be given if necessary.

Local wound management
Gunshot wound should never be closed primarily at the first surgical episode. Delayed primary closure or healing by secondary intention is the mainstay of soft tissue reconstruction following GSW.[8]

Fracture management
Fixation of fractures from gunshot injuries can be managed in a similar manner to those from other mechanisms. Bone fractures should be stabilized temporarily with an external fixator.

Ballistic fractures are very slow to heal and this should be borne in mind when considering possibility of non-union.[8]

Should the bullet be removed for all gunshot injury?
No, not all retained bullets need to be removed. Most bullets shot from civilian firearms that are retained in soft tissue or muscles are from low velocity weapons and need only be removed if problems arise after acute soft tissue swelling has subsided.

It is uncommon that operation is performed sorely for the purposes of bullet removal. On one hand, retained bullets rarely cause complication. On the other hand, surgical attempts to find and remove these bullets usually cause more harm than good.

In general, the indications for bullet removal include

1. Superficial and residing in a pressure area where the bullet is painful to the patient
2. Visibly bulging beneath the skin and causing cosmetic distress
3. In a joint space
4. In the globe of the eye
5. In a vessel lumen causing ischaemia or at risk of embolization
6. Impinging on a nerve and causing pain
7. Localized abscess formation (usually due to dirt or clothing fragment entrained by the bullet)
8. Required for forensic investigation and the patient and surgeon are in full agreement that the removal will not result in increased pain, suffering, complications or injury and both agree to the removal.
9. Documented elevated lead levels, usually in a child and occurring several months after injury (extremely rare)

Progress of patient

Emergency operation with wound debridement, removal of bullet and open reduction and internal fixation of the fracture fragment were performed. All instruments used for removal of bullet were covered by a plastic cover.

X-ray of right knee was taken after the operation. (Figure 12)

Figure 12: X-ray of right knee after operation

Why is it important to use a plastic covered instrument on removal of bullet?

Direct contact of the bullet with metallic objects e.g. probes, forceps or scalpel blades may induce scratches or other marks on the surface of a bullet.

The surfaces of a bullet may be examined for the striation which is the tiny scratch on the surface induced by the rifling of the gun's barrel. This striation can be used to trace back the gun from which it fired. Scratches or marks induced during operation may interfere with forensic examination.

Should we notify the police for all gunshot wounds?

We should notify the police for all gunshot wounds. As an emergency physician, we should carefully evaluate, document and preserve potential forensic evidence while simultaneously provide appropriate care.

The anatomical location, shape, size, and associated findings such as soot or powder burns should be noted. A detailed description of wounds is preferred compared to attempt to identify and differentiate entrance vs. exit wounds as such differentiation may have significant medicolegal implications if done incorrectly.

A practical approach includes cutting around, but not through, bullet holes when removing a patient's clothing. Ensure all the patient's clothes, belongings and any missile fragments are retained, bagged, labeled and kept secure until passed on to the police.

Documentation should include any treatment to the wounds. Consider photographing the wounds, if possible.

Progress of patient

The patient was put on non-weight bearing walking for 6 weeks together with a hinged knee brace locked at full extension on the right knee. He was discharged on Day 3 of admission.

Reference

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