THE MECHANISM OF THE HUNTING ARROW

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An arrow with a broad bladed razor-sharp point has a rapid mortal effect when penetrating the chest of a game.

This effect derives from a quick clearing of blood causing acute hypoxia, from suspended lung function or a combination of both.

BLOOD PRESSURE AND PHYSIOLOGY OF BLOOD LOSS

The blood pressure in arteries of caribou is 130-155 mm Hg in the systolic phase of the heart (1).
Presumably, that of other deer-species is approximately identical. This means that the heart applies a pressure to the blood which would raise mercury approximately 150 mm. Mercury has a specific gravity of 13,6 times that of water, so this corresponds to raising a pillar of water/blood 13,6 x 150 mm, i.e. 2 meters, approximately 7 feet. A cut artery pointed upwards would by each contraction of the heart eject the blood 2 meters right up in the air. The mean blood pressure through all the heart´s working phases is lower, approximately 125-100 mm Hg. (1,2).

The only arteries in which the above pressures do not apply are the arteries of the lungs. The blood pressure there is about 20 mm Hg in the heart´s systolic phase, averaging 15 mm Hg. (2)

The blood pressure in the veins is considerably lower- only 3 to 10 mm Hg. A solitary venous bleeding is thus never acutely fatal.

When by profuse bleeding the blood volume of the hit animal rapidly decreases the automation of circulation attempts to compensate this. This happens partly by increase of pulse, partly by redistribution of blood from the body surface, the intestines and the bones to the heart, the brain and the muscles.
This automation is controlled both by the release of stress hormones, primarily adrenalin, and by nervous reflexes. (2).
The same pattern can be extremely accentuated in case that the wounded animal is frightened. In this case, its shock-resistance is strengthened by increased adrenalin secretion. The adrenalin increases the heart´s frequency and degree of contraction, thereby liberating power of escape.

A rapid blood volume reduction of 20% can in this fashion be compensated with retained blood pressure and thus full vitality in the animal (3). If the blood loss gets larger, the animal goes into a state of shock.
This involves lowered blood pressure, high pulse, decreased consciousness and increased anxiety, pale mucous membranes and the appearance of overwhelming thirst. Given the opportunity, the animal will seek water to drink. Out of weakness, it will seek an appropriate hiding place in order to rest.

With increased blood loss, the central functions of the organism can no longer be sustained, so the animal loses consciousness and dies. This occurs at approximately 35% blood loss it this blood loss is quick. (3)

THE BLOOD VOLUME AND THE BLOOD VESSELS

A deer (whitetail - or mule-) with a dressed weight of 45 kg has a live blood volume of 2.8 litres (3). A 20% blood loss for which the deer can compensate is thus 0.6 litres. A 35% blood loss, which is mortal, corresponds to 1.0 litres of blood.

The dressed weight of a mature female fallow deer is stated as 35 kg of the mature red stag 101-120 kg (4). With the same relation to bodyweight, 35% of the blood volume is in the first case 1.1 litres, in the later 3.2 to 3.7 litres.

In the roe deer with a dressed weight of 20 kg, 35% blood loss is 0.4 litres.

The diameter of the chest arteries of the roe deer has been measured to from 1.5 cm (the beginning of the lung-artery) and less. The inner diameter of the Aorta is an average of 1.0 cm. The diameter of the arteries decreases as the gradually branch out. Most branches in the Thorax to lungs, neck, head and forelegs have an inner diameter of 0.5 cm. (Measurements made by author).

THE TIME SEQUENCE

1 Bleeding

The velocity of blood loss by a ruptured vessel primarily depends on the blood pressure, the resistance in surrounding tissues, the distance from the heart and the maximal pumping capacity of the heart (in man normally 1 litre per 10 seconds. (2)).
When the heart or the Aorta is cut, the blood pressure ceases almost instantly, the blood supply to the brain stops an unconsciousness occurs within 8-15 seconds. The brain cells are irreversibly damaged and die after 4-5 more minutes. In case of an arrow hit in the central lung area several of the lung arteries will invariably be cut. To some extent the bleeding time can be illustrated by water running from three hoses with an inner diameter of 0,5 cm and the pressure of the lung arteries. 0,5 litres will last 6 seconds.

2 BILATERAL COLLAPSE OF THE LUNGS

The lungs are extremely elastic organs suspended with their outer surface in close contact with the walls of the chest cavity and to the diaphragm, which separates the chest cavity from the abdominal cavity. What keeps them suspended is the vacuum in the pleurae - the narrow gaps between the lungs and the chest cavity -, which allow the lungs to glide frictionless against the wall of the chest cavity during breathing. If the pleura is punctured, thereby letting in air, the vacuum gradually disappears as the air enters. The result is a contraction of the lung due to its own elasticity, finally adopting a volume of one seventh of the original. Through the disappearance of the vacuum in the pleura by puncture, the lung ceases to be a respiratory organ.
By unilateral puncture of the pleura, the respiratory capacity remains in the other lung thereby supplying sufficient oxygen exchange for the animal´s vital functions. If on the other hand both pleurae are punctured, the lungs gradually cease to function as air is sucked into the pleura cavity by the respiratory movements. The animal suffers acute lack of oxygen and dies.
The time sequence to unconsciousness by bilateral lung collapse varies between 1 and 5 minutes depending on the size of the puncture. As this wound is practically always combined with serious haemorrhage, the time sequence is often short. Only in the case of high hits in the lungs will the lung collapse therefore be the dominant cause of death.

BLEEDING IMPEDING MECHANISMS

By damage to medium sized arteries, such as those to the bones or to the digestive tract, or to smaller arteries different mechanisms come into function attempting to stop the bleeding.
The major ones are:

1. Formation of thrombosis in the damaged vessel.
2. Arterial spasm.
3. Coagulation of blood.
4. Pressure rise in the tissue around the damaged vessel.

1. Formation of thrombosis (4)

An artery, which is partially or totally severed, can shortly stop bleeding by contraction of the vessel around the thrombosis. This occurs if sufficiently extensive damage has hit the vessel.
The mechanism is initiated by the damaged walls of the blood vessel causing the blood platelets to attach and rapidly aggregate to a seal, which closes off the vessel.
Substances liberated by the damage cause a tough network of fibrin to form in the clot making it durable.
Simultaneously with the formation of the clot, the arteries contract around it by spasm in the muscular layer of the vessel wall.
The more extensive the damage to the wall of the vessel, the more efficient and quick is the development of the clot and the contraction.

2. Arterial spasm (5)

A damaged artery can develop a spasm in the muscular layer of the vessel wall, which contracts the vessel making in narrower. The spasm can include several centimetres of the length of the artery and can be so strong as to cut off the blood flow completely. Arterial spasm most often occurs in case of blunt violence to the artery or by a stretch damage.

3. Coagulation

Coagulation is the blood´s ability to get stiff. This can occur in two ways.

A slow coagulation reaction starts by the inner wall of the vessel activating a protein, which is the first element in a chain of slow reactions, which finally activate the very rapid terminal phase of blood coagulation.

A quick coagulation reaction starts with a lipid agent being released from damaged tissue. In the case of a major tissue damage to and around a vessel a sufficient amount of this agent is released to directly activate the rapid terminal phase of the coagulation. Blood therefore coagulates more quickly the more cells are damaged in and around a blood vessel.

4. Increased pressure in the tissue around the damaged vessel.

In cases where the damaged artery is situated in a muscle or between other strong tissues structures the bleeding is quickly reduced by the increasing pressure arising around the vessel.
In cases where the damage decently lacerates the tissue around the damaged vessel or if the surrounding tissue is softer like for instance in the chest of the abdominal cavity the blood flow meets less resistance and the bleeding can take place freely.

An arrow provided with a broadhead opens up sufficiently large cavities for the bleeding not to be impeded by increased tissue pressure. This effect is strengthened by cut musclefibers by means of their own tension pulling them apart like a tense elastic band, which is cut.

RAZOR-SHARP BROADHEADS

The 3 previously mentioned mechanisms which may reduce or stop an arterial bleeding are all activated the more strongly the more extensive the damage is to the vessel or the surrounding tissue.
This is the reason why the bowhunters must have razor-sharp edges on his broadheads. This also explains why the evacuation of blood may happen more rapidly when the game is hit with an arrow as opposed to an expanding bullet. Likewise, why the surface of hit on the game, which leads to a quick killing effect, is larger for the broad bladed razor-sharp broadhead than it is for the expanding bullet.

CRIPPLING NOT SO SERIOUS AS WITH BULLET

A hit in only skin or muscle tissue with a razor-sharp broadhead is much less serious to the crippled animal than a similar hit with a rifle bullet. A hunting arrow causes a relatively clean wound into which much fewer skin and hair particles are introduced. In muscle tissue, such a wound bleeds profusely with an inner cleaning effect. The arrow hit causes no remote damage at all and the local damage is free of contusion.
This type of wound normally heals quickly and without complications without influencing the general state of health of the animal.

A similar hit with an expanding bullet, especially high-velocity bullets, causes extensive contusion damage locally with invasion of skin and hair particles. Besides remote effect from fragments of bone tissue and bullet maybe also the explosion effect of a pulsating cavity. This type of damage has a much worse risk of causing wound infection, blood poisoning, multiple thrombosis, shock effect from poisonous decomposition products from the damaged tissue and impeded healing.
This causes more pain not long after the hit, long-lasting agony later on and primarily considerably less chance for the animal to survive the crippling.

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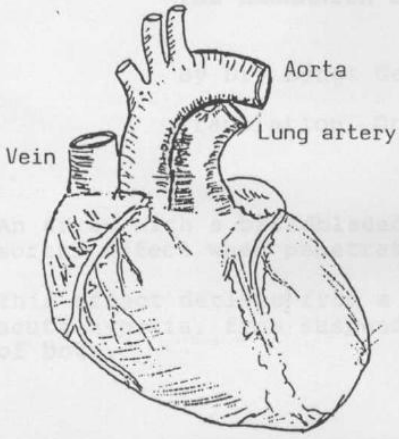
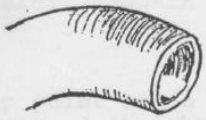
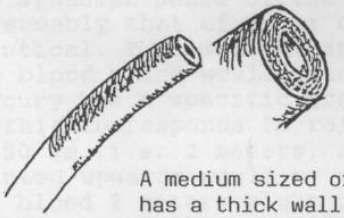
Arteries of front leg and head



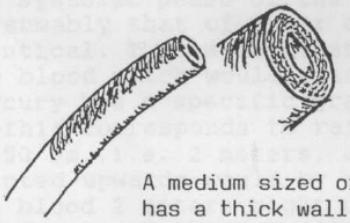
HEART (front)



The wall of aorta is thin and consists mainly of elastic fibrers without contraction ability



A medium sized or smaller artery has a thick wall with a strong layer of circular muscle fibrers



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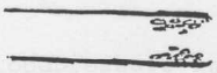
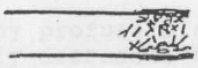
THROMBOSIS



1. Gathering of blood plates

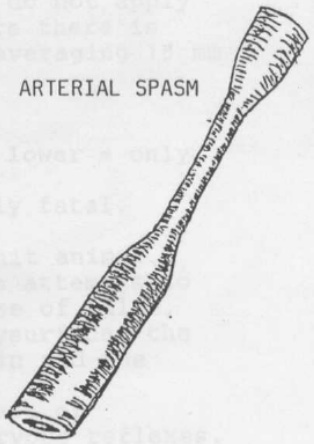


2. Formation of fibrin

3. Fibrin clot

4. Clot with vascular wall spasm

ARTERIAL SPASM



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