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RESEARCH ARTICLE

Caisson disease

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Abstract

Caisson disease also known as Decompression sickness (DCS), describes a condition arising from dissolved gases coming out of solution into bubbles inside the body on depressurisation. It is the one of the medical emergency and needs immediate medical attention.

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Introduction:-

Caisson disease also known as Decompression sickness (DCS), divers' disease or the bends describes a condition arising from dissolved gases coming out of solution into bubbles inside the body on depressurisation. DCS most commonly refers to problems arising from underwater diving decompression (during ascent), but may be experienced in other depressurisation events such as working in a caisson, flying in unpressurised aircraft, and extra-vehicular activity from spacecraft.

DCS is a subset of Decompression illness (DCI) which includes both DCS and Arterial gas embolism (AGE).

Classification:-

- DCS is classified in the following manner based upon the symptoms,
  - Bends - for joint or skeletal pain
  - Chokes - for breathing problems
  - Staggers - for neurological problems.
- Golding's classification
  - Type I ('simple') for symptoms involving only the skin, musculoskeletal system, or lymphatic system,
  - Type II ('serious') for symptoms where other organs (such as the central nervous system) are involved. Type II DCS is considered more serious and usually has worse outcomes.

Causes:-

- Reduction in ambient pressure
- Leaving a high-pressure environment
- Ascending from depth, or ascending to altitude.

Predisposing factors:-

Although the occurrence of DCS is not easily predictable, many predisposing factors are known. They may be considered as either environmental or individual.

Environmental:-

The following environmental factors have been shown to increase the risk of DCS:

- The magnitude of the pressure reduction ratio – a large pressure reduction ratio is more likely to cause DCS than a small one.
- Repetitive exposures – repetitive dives within a short period of time (a few hours) increase the risk of developing DCS. Repetitive ascents to altitudes above 5,500 meters (18,000 ft) within similar short periods increase the risk of developing altitude DCS.
- The rate of ascent – the faster the ascent the greater the risk of developing DCS. The duration of exposure – the longer the duration of the dive, the greater is the risk of DCS. Longer flights, especially to altitudes of 5,500 m (18,000 ft) and above, carry a greater risk of altitude DCS.
- Underwater diving before flying – divers who ascend to altitude soon after a dive increase their risk of developing DCS.

Individual:-

Atrial septal defect showing left-to-right shunt. A right-to-left shunt may allow bubbles to pass into the arterial circulation.

The following individual factors have been identified as possibly contributing to increased risk of DCS:

- Dehydration
- Patent foramen ovale
- Age
- Previous injury
- Ambient temperature
- Body type – typically, a person who has a high body fat content is at greater risk of DCS.
- Alcohol consumption

Pathophysiology :-

This surfacing diver must enter a decompression chamber for surface decompression, a standard operating procedure to avoid decompression sickness after long or deep bounce dives. Depressurisation causes inert gases, which were dissolved under higher pressure, to come out of physical solution and form gas bubbles within the body. These bubbles produce the symptoms of decompression sickness. Bubbles may form whenever the body experiences a reduction in pressure, but not all bubbles result in DCS. The amount of gas dissolved in a liquid is described by which indicates that, when the pressure of a gas in contact with a liquid is decreased, the amount of that gas dissolved in the liquid will also decrease proportionately.

On ascent from a dive, inert gas comes out of solution in a process called "out gassing" or "off gassing". Under normal conditions, most off gassing occurs by gas exchange in the lungs. If inert gas comes out of solution too quickly to allow out gassing in the lungs then bubbles may form in the blood or within the solid tissues of the body. The formation of bubbles in the skin or joints results in milder symptoms, while large numbers of bubbles in the venous blood can cause lung damage. The most severe types of DCS interrupt — and ultimately damage — spinal cord function, leading to paralysis, sensory dysfunction, or death. In the presence of a right-to-left shunt of the heart, such as a patent foramen ovale, venous bubbles may enter the arterial system, resulting in an arterial gas embolism. A similar effect, known as ebullism, may occur during explosive decompression, when water vapour forms bubbles in body fluids due to a dramatic reduction in environmental pressure.

Inert gases:-

The main inert gas in air is nitrogen, but nitrogen is not the only gas that can cause DCS. Breathing gas mixtures such as trimix and heliox include helium, which can also cause decompression sickness. Helium both enters and leaves the body faster than nitrogen, so different decompression schedules are required, but, since helium does not cause narcosis, it is preferred over nitrogen in gas mixtures for deep diving. There is some debate as to the decompression requirements for helium during short-duration dives. Any inert gas that is breathed under pressure can form bubbles when the ambient pressure decreases. Very deep dives have been made using hydrogen-oxygen mixtures (hydrox), but controlled decompression is still required to avoid DCS.

Isobaric counter diffusion:-

DCS can also be caused at a constant ambient pressure when switching between gas mixtures containing different proportions of inert gas. This is known as isobaric counter diffusion, and presents a problem for very deep dives.

Bubble formation:-

The location of micronuclei or where bubbles initially form is not known. The most likely mechanisms for bubble formation are tribonucleation, when two surfaces make and break contact (such as in joints), and heterogeneous nucleation, where bubbles are created at a site based on a surface in contact with the liquid. Homogeneous nucleation, where bubbles form within the liquid itself is less likely because it requires much greater pressure differences than experienced in decompression. The spontaneous formation of nanobubbles on hydrophobic surfaces is a possible source of micronuclei, but it is not yet clear if these can grow large enough to cause symptoms as they are very stable.

Once microbubbles have formed, they can grow by either a reduction in pressure or by diffusion of gas into the gas from its surroundings. In the body, bubbles may be located within tissues or carried along with the bloodstream. The speed of blood flow within a blood vessel and the rate of delivery of blood to capillaries (perfusion) are the main factors that determine whether dissolved gas is taken up by tissue bubbles or circulation bubbles for bubble growth.

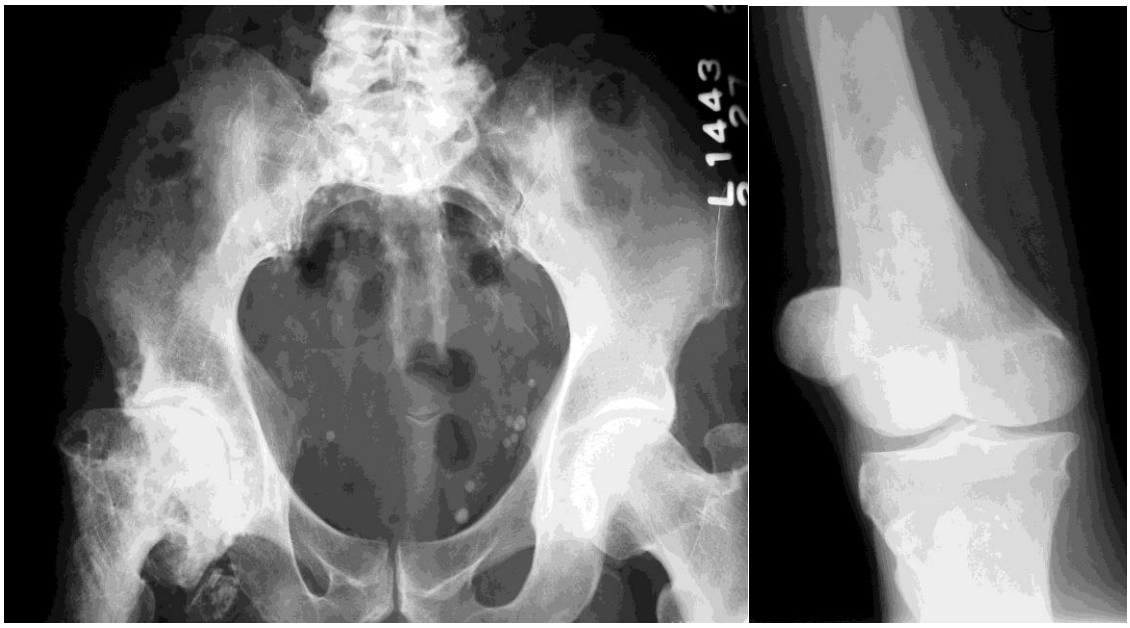
Signs and symptoms:-

While bubbles can form anywhere in the body, DCS is most frequently observed in the shoulders, elbows, knees, and ankles. Joint pain ("the bends") accounts for about 60% to 70% of all altitude DCS cases, with the shoulder being the most common site. Neurological symptoms are present in 10% to 15% of DCS cases with headache and visual disturbances being the most common symptom. Skin manifestations are present in about 10% to 15% of cases. Pulmonary DCS ("the chokes") is very rare in divers and has been observed much less frequently in aviators since the introduction of oxygen pre-breathing protocols. The table below shows symptoms for different DCS types.

Signs and symptoms of decompression sickness		
DCS type	**Bubble location**	**Signs & symptoms (clinical manifestations)**
Musculoskeletal	Mostly large joints (elbows, shoulders, hip, wrists, knees, ankles)	• Localized deep pain, ranging from mild to excruciating. Sometimes a dull ache, but rarely a sharp pain. • Active and passive motion of the joint aggravates the pain. • The pain may be reduced by bending the joint to find a more comfortable position. • If caused by altitude, pain can occur immediately or up to many hours later.
Cutaneous	Skin	• Itching, usually around the ears, face, neck, arms, and upper torso • Sensation of tiny insects crawling over the skin (fornication) • Mottled or marbled skin usually around the shoulders, upper chest and abdomen, with itching • Swelling of the skin, accompanied by tiny scar-like skin depressions (pitting oedema)
Neurologic	Brain	• Altered sensation, tingling or numbness (paresthesia), increased sensitivity (hyperesthesia) • Confusion or memory loss (amnesia) • Visual abnormalities • Unexplained mood or behaviour changes • Seizures, unconsciousness
Neurologic	Spinal cord	• Ascending weakness or paralysis in the legs • Urinary incontinence and faecal incontinence • Girdling (also referred to as girdle, banding, or tightening feeling) around the abdominal region and/or chest
Constitutional	Whole body	• Headache • Unexplained fatigue • Generalised malaise, poorly localised aches
Audio vestibular	Inner ear	• Loss of balance • Dizziness, vertigo, nausea, vomiting • Hearing loss
Pulmonary	Lungs	• Dry persistent cough • Burning chest pain under the sternum, aggravated by breathing • Shortness of breath

Symptoms by frequency:

Symptoms	Frequency
Local joint pain	89%
Arm symptoms	70%
Leg symptoms	30%
Dizziness	5.3%
Paralysis	2.3%
Shortness of breath	1.6%
Extreme fatigue	1.3%
Collapse/unconsciousness	0.5%



The distribution of symptoms of DCS :

Onset of DCS symptoms	
Time to onset	**Percentage of cases**
within 1 hour	42%
within 3 hours	60%
within 8 hours	83%
within 24 hours	98%
within 48 hours	100%

Although onset of DCS can occur rapidly after a dive, in more than half of all cases symptoms do not begin to appear for at least an hour. In extreme cases, symptoms may occur before the dive has been completed.

Diagnosis:-

Decompression sickness should be suspected if any of the symptoms associated with the condition occurs following a drop in pressure, in particular, within 24 hours of diving

Prevention:-

Using basic personal dive computer, it shows the depth, dive time, and decompression information.

Breathing pure oxygen significantly reduces the nitrogen loads in body tissues by reducing the partial pressure of nitrogen in the lungs, which induces diffusion of nitrogen from the blood into the breathing gas, and this effect eventually lowers the concentration of nitrogen in the other tissues of the body.

Treatment:-

The recompression chamber

- All cases of decompression sickness should be treated initially with 100% oxygen until hyperbaric oxygen therapy (100% oxygen delivered in a high-pressure chamber) can be provided.
- Mild cases of the "bends" and some skin symptoms may disappear during descent from high altitude; however, it is recommended that these cases still be evaluated.
- Neurological symptoms, pulmonary symptoms, and mottled or marbled skin lesions should be treated with hyperbaric oxygen therapy if seen within 10 to 14 days of development.
- Recompression on air was shown to be an effective treatment for minor DCS symptoms.
- It is beneficial to give fluids, as this helps reduce dehydration.
- It is no longer recommended to administer aspirin, unless advised to do so by medical personnel, as analgesics may mask symptoms.
- People should be made comfortable and placed in the supine position (horizontal), or the recovery position if vomiting occurs. In the past, both the Trendelenburg position and the left lateral decubitus position (Durant's maneuver) have been suggested as beneficial where air emboli are suspected.

Prognosis:-

Immediate treatment with 100% oxygen, followed by recompression in a hyperbaric chamber, will in most cases result in no long-term effects. However, permanent long-term injury from DCS is possible.

Conclusion:-

The caisson’s disease or the decompression sickness needs immediate medical care and management, but at the same time it can be prevented through proper adoption of preventive therapies as mentioned above. So the divers can adopt those things to avoid complications.

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