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Plan

- Physiological aspect
- Methodology
- Results
- Discussion

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Physiological aspect

- Osteonecrosis = is not a specific disease entity but the final common pathway of a number of conditions leading to bone death.
- Avascular osteonecrosis
- Dysbaric osteonecrosis

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Avascular osteonecrosis

- More often in the hips
- Favorising factors

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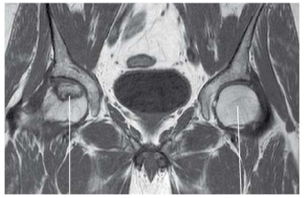
Diagnostic

- Gold Standard: MRI
- Classification: Ficat and Arlet



Stage	Radiological findings
I	Plain radiograph, magnetic resonance imaging, and scintigraphy: normal
IIA	Sclerotic and cystic lesion (absence of subchondral cystic formation)
IIB	Subchondral collapse (crescent sign) and/or subchondral aliasing
III	Irregular femoral contour
IV	Collapse of the femoral head, acetabular involvement, and articular destruction (osteoarthritis)

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Treatment

- Symptomatic
- Physiotherapy
- 20% evolution to early osteoarthritis
- Articular replacement

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DON Vs AVN

- Etiological diagnosis is assumed

- Radiographical evidence (RX-CT-MRI)
- in context of diving,
- excluding other causes of AVN

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Dysbaric osteonecrosis

- Osteonecrosis is the consequence of a desaturation accident in the bone
- Dysbaric Osteonecrosis in tunnel workers vs. sports divers
- Incidence from 2.5% to 70%
- Tunnel workers: occupational disease
  - Long periods of work under pressure
  - Non-adapted decompression schedules
  - Frequent denial of pain (loss of income)
  - Slow development of symptoms (arthrosis)

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Dysbaric osteonecrosis

- Decompression sickness classification
- Pain in joints = Type I DCS
- Untreated → possible necrosis (DON)
- Consequence depends of the site of the lesion
- Peri-articular 2/3 vs. diaphysis (in the main bone)

Table 1
"Historical" classification of decompression sickness (adapted from [5,11] after [3]).

	Type I DCS	Type II DCS
Classification	Non-systemic, peripheral, "minor"	Systemic, serious
Symptoms	Pain – Joint and tendon pain	Cerebral–cerebellar – Altered consciousness – Visual disturbances – Auditory, vestibular symptoms
	Lymphatic – Localised lymphatic congestion	Spinal – Paralysis, paresis – Bladder or bowel dysfunction – Sensory disturbances
	Cutaneous symptoms – Itching – Rash – Localised cyanosis – Cutis Marmorata	Pulmonary – Dyspnea, cough – Desaturation
		Circulatory – Shock

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Physiological aspect

- Sports divers: pain-only DCS less frequent than neurological DCS
  - Treatment no consequence on income
  - Treated more rapidly (…)
  - Virtually no DON detected over past 20 years

CHBO DCS database	1994-2004 (n=157)	2004-2014 (n=209)
Peripheral Neuro :	35%	19%
Central Neuro :	30%	10%
Pain only (type I) :	20%	15%
Skin bends :	5%	53%
AGE :	7%	3%
Clearly mixed :	3%	-

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Methodology

- Methods:
  - Population
  - Investigation
  - Evaluation
- Results
  - Population data
  - CT results

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Hypothesis

- Deep divers
- Rebreathing systems
- Go as far, as long as possible

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Population

- Divers > 18 years old
- More than 30 deep dives (> 60m) in the last 5 years
- Asymptomatic at the time of the study

- Total 27 "deep recreational divers"

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Population

	Population divers (n=27)	
Gender: Men Women	25 2	92,6 % 7,4 %
Age	49 ans	DS 10,6
Height cm	177,8	DS 6,6
Weight kg	85,7	14,3
BMI	27,1	4,2
Smoking	1	3,7 %
Regulary alcohol consumption	24	88 %
Average alcohol	0 à 5 unit/week	
Medication	6	22
Heart issue	1	3,7 %
Pulmonary issue	1	3,7 %
Diabetis	0	0 %
Thyroid issue	0	0 %
Liver issue	0	0 %
Kidney issue	0	0
HIV +	0	0 %
Use of corticoid in the past 10 years	2	7,4 %

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Investigation

- Questionnaire : more details on what has been asked
- CT Scan

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Investigation - Questionnaire

Questionnaire:
General:
Last name - First Name : .....
Gender: Male Female Other
Age: .....
Weight: ..... kg Height: ..... cm
Do you smoke? Yes No
If yes, How many per day? 0-10 10-20 >20
Do you drink alcohol? (Including wine and beer): Yes No
If yes, how many per week? 0-5 Units 6-10 Units > 11 Units
Do you take medication every day/week? Yes No
Which? .....
Did you have any surgery in the past? Yes No
Which? .....
Do you have currently any health concerns? Yes No
Heart ? (Insufficiency, High blood pressure, arrhythmia…) Yes No
Please specify? .....
Lungs ? (COPD, Asthma, Emphysema …) Yes No
Please specify? .....
Diabetes? Yes No
Thyroid disorder? Yes No
Which (Hypo/hyper thyroidal, thyroiditis)?.....
Affection of the kidneys?
Please specify? .....
Affection of the liver?
Please specify? .....
Are you tested positive for HIV? Yes No
Have you been treated, in the past ten years, by corticoid? Yes No
Please specify? .....

Diving:
How many years do you dive ? .....
How many dives have you done in total ? .....
How many dives per year do you do, the last 5 years ? 0-20 21-40 > 40
How many deep dives (> 60 meter) are you doing each year?
0-5 6-10 11-20 > 20
On average, on diving days do you do more than 1 dive per day ? Yes No
If yes, how many dives in a day ? 1-2 3-4 > 4
Which gases do use for diving ? Air Nitrox Trimix
Do you dive with a rebreather? Yes No
If yes, which type (+ brand) : .....
Which dive computer(s) do you use ? .....
Did you have a dive accident/incident in the past ? Yes No
If yes, in what year ? .....
Which symptoms ?
Cutaneous rash,
Strange feeling (paresthesia) in your legs of arms,
Vertigo,
Difficulty breathing after the dive,
Cough with bloody sputum,
Loss of consciousness,
Other (please describe) .....
Were you treated in a hyperbaric chamber for those symptoms ? Yes No
If yes, in which hyperbaric centre ? .....
Do you have any remarks of any other information to add ? .....

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Population

33% (9/27) of the divers report a dive accident

Symptomes of the previous dive accident

Cutaneous rash	44,4 %
Tingling	22,2 %
Dizziness	44,4 %
Joint pain	33,3 %
Other	44,4 %

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Investigation – CT Scan

- CT scan:
  - Rationale why CT scan:
    - Availability in MHKA
    - Rapid examination
    - Low radiation dose
    - Established lesions detected vs (MRI – early lesions)
- Ethics approval needed
  - What to do with detected DON lesions ?
  - What with other findings on CT if important ?

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Investigation - CT Scan

- CT Scan
  Classification after the *United Kingdom Medical Research Council*

Classification of dysbaric osteonecrosis lesions (after the United Kingdon Medical Research Council). * = classification of the present case

Lesion	Subtype	Comments
A type lesions Juxta-articular:	A1 Dense area with intact articular cortex	Prevalence of A lesions:
	A2 Spherical opacities	
	A3 Linear opacities	Tunnellers and saturation divers
	A4 Structural failures	Femur > Humerus
	- Translucent subcortical bands	
	- Collapse of articular cortex	
	- Sequestration of cortex*	Other divers
	A5 Secondary degenerative osteoarthritis	Humerus > Femur
B type lesions Shaft	B1 Dense areas	
	B2 Irregular calcified areas	n/a
	B3 Translucent and cystic areas	

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Results

- 3/27 with radiological signs of osteonecrosis

Results of the CT Scan						
Divers	Number of dive	Dive / year	Age	BMI	Localisation	Stadification
1	800	> 40	60	20,8	Humérus proximal	A1 + B3
2	300	> 40	53	23,8	Humérus proximal	A2 + B3
3	2000	> 40	64	25,8	Humérus proximal	A4 + A1

Classification of dysbaric osteonecrosis lesions (after the United Kingdon Medical Research Council). * = classification of the present case

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	- Translucent subcortical bands	
	- Collapse of articular cortex	
	- Sequestration of cortex*	Other divers
	A5 Secondary degenerative osteoarthritis	Humerus > Femur
B type lesions Shaft	B1 Dense areas	
	B2 Irregular calcified areas	n/a
	B3 Translucent and cystic areas	

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Results

Résultat scanner	
Osteonecrosis present	11,1 %
Localisation Humerus proximal Humerus distal Thighbone proximal Thighbone distal	 100 % 0 % 0 % 0 %
Side Left Right	 50 % 50 %
Unilateral Bilateral	66 % 33 %
Use of Corticoids	0 %

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Discussion

- 3/27 divers had radiological signs of osteonecrosis
- No symptoms
- 2 of the 3 divers do **not** report any dive accident before
- None of them had used corticoids in the previous 10 years

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Discussion

- Models of decompression
  - Haldane
  - Neohaldanean
  - Bubble models
- Statistical risk of DCS with these models: 0.5-2%
  (US Navy, DAN Europe database)
- Trimix diving: not necessarily comparable to “2-gas” diving
  - Yet: decompression models extrapolated from “older” models
  - Statistical risk for DCS unknown, but (much) higher than air/nitrox diving (cf DAN Statistics)

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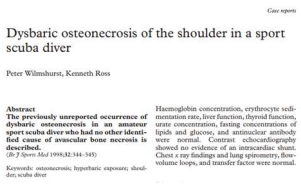
Discussion



Case reports

Dysbaric osteonecrosis of the shoulder in a sport scuba diver

Peter Wilmshurst, Kenneth Ross

Abstract
The previously unreported occurrence of dysbaric osteonecrosis in an amateur sport scuba diver who had no other identified cause of avascular bone necrosis is described.
(*Br J Sports Med* 1998;32:344–345)

Keywords: osteonecrosis; hyperbaric exposure; shoulder; scuba diver

Haemoglobin concentration, erythrocyte sedimentation rate, liver function, thyroid function, urate concentration, fasting concentrations of lipids and glucose, and antinuclear antibody were normal. Contrast echocardiography showed no evidence of an intracardiac shunt. Chest x ray findings and lung spirometry, flow-volume loops, and transfer factor were normal.

- DCS Type I often asymptomatic ?

  DON often without history of DCS
- DON described in recreational SCUBA only from 1998 – since then, increasing reports in deep or tech divers
- Hypothesis:
  - DON more frequent than previously thought ?
  - Prediction P Wilmshurst: "*Failure to learn from past lessons may cause amateur divers to suffer an epidemic of dysbaric osteonecrosis, similar to those in professional divers earlier in this century, before safer work practices were introduced to those occupations.*"

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Discussion:

- 11% of divers had DON
- None had symptoms, none had other risk factors for AVN, localisation "typical" for DON, not typical for AVN → DON most likely cause
- Only 1 in 3 reported previous DCS
  - Denial ?
  - Asymptomatic ?

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Discussion

- Reason for DON ?
  - Long, deep dives with Trimix → "= long, shallower dives with air" = typical dive profile for tunnel workers ?
  - Dive computers "not reliable" for Trimix ?
  - Shoulders vs hips: less "work" with legs, more with arms (manipulating heavy dive gear before and after dive, scooter during dive, … ?)

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Discussion

- CAVEAT:
  - No imaging from BEFORE diving activity
  - "Older divers", more affordable rebreather equipment
  - Only CCR divers in sample – typically longer dives than Open Circuit Trimix (dive computers might be more reliable for OC deep diving ?)
  - Dive computer settings: "more conservative" (cf Gradient Factors) may be not always safer

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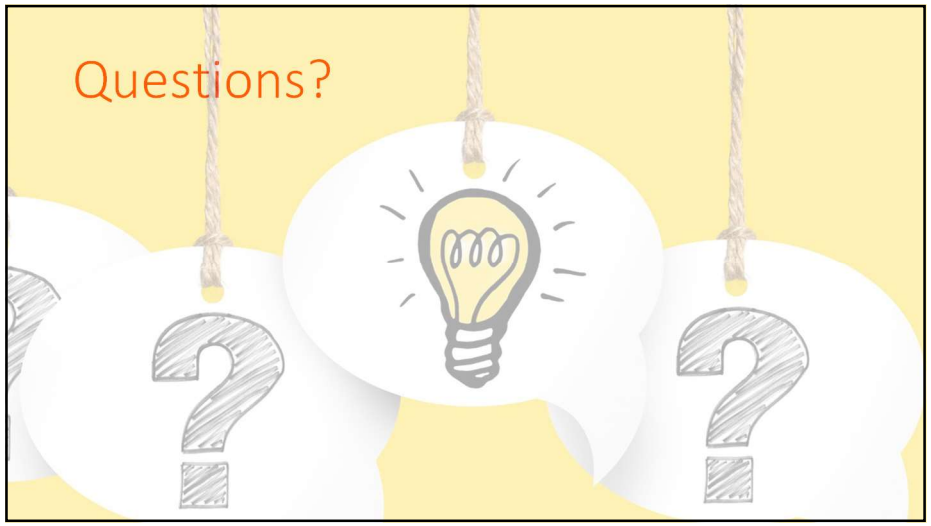

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