



Patient organ radiation doses during treatment for aneurismal subarachnoid hemorrhage, SAH

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Background



- Subarachnoid Haemorrhage (SAH), from rupture of an intracranial aneurysm, occurs between 8 and 23 per 100.000 and is most common in women.
- SAH is a devastating condition, with mortality rates as high as 45% and significant morbidity.
- Endovascular (image-based) therapy resulted in decreased mortality and morbidity, but also in high head doses.





Aims



- To estimate doses to **skin, brain, salivary gland, oral mucosa, eye lens** and **thyroid** during the imaging-intensive phase of the treatment.
- To estimate stochastic risk and the frequency of tissue reactions.
- Develop and implement local guidelines for management of these risks at our hospital.



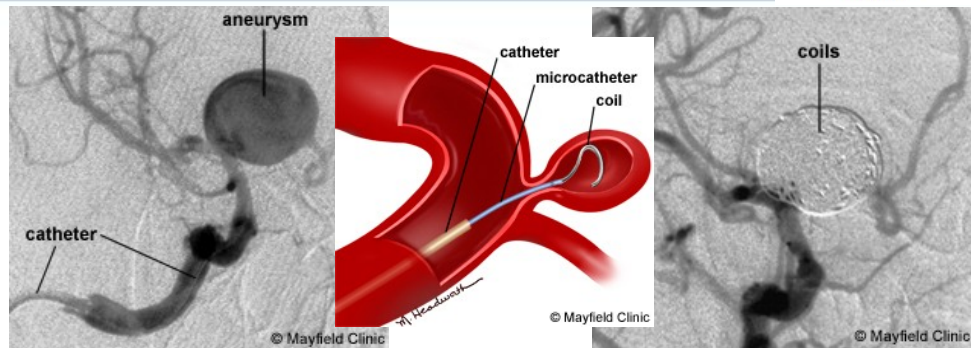


Patient material

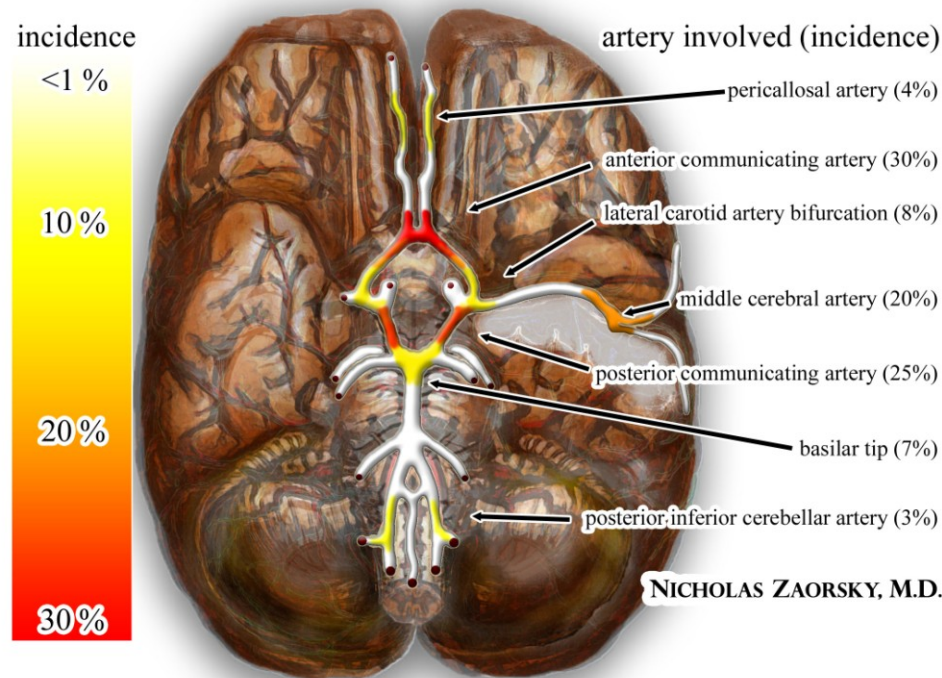
- 50 patients (38 women and 12 men)

- Inclusion criteria:

SAH caused by ruptured intracranial saccular aneurysms that were occluded using endovascular coiling and treated at the NSICU.



Most common sites of intracranial saccular aneurysms





Diagnostic imaging work-up



1. CT on arrival for SAH diagnosis (emergency)
2. CTA (CT angiography) for aneurysm diagnosis
3. Endovascular coiling, DSA, 3D in coiling lab
4. CT head 4-12 hours after aneurysm occlusion
5. CT head in case of clinical deterioration
6. CT to follow up hydrocephalus development
7. Xe-CT (cerebral blood flow) for suspected vasospasm typically 4-10 days after SAH
8. CT when discharged from NSICU in Linköping





Clinical results - outcome



H & H	Glasgow Outcome Scale, GOS-score on follow-up (N = 50)					Total
	GOS 5: Good recovery	GOS 4: Moderate disability	GOS 3: Severe disability	GOS 2: Chronic vegetative state	GOS 1: Dead	

80% Good recovery or only mild disability (%)

20% severe disability or died (GOS < 4) (%)

All patient that died from their decease were initially very sick (H&H > 2) (%)

Total	29 (58%)	11 (22 %)	4 (8 %)	-	6 (12 %)	50 (100 %)
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Hunt and Hess grade H&H 1: Asymptomatic, mild headache, slight nuchal rigidity

Hunt and Hess grade H&H 5: Coma

Glasgow Outcome Scale GOS 1: Dead

Glasgow Outcome Scale GOS 5: Good recovery



Patient age and total P_{KA} , P_{KL}



	Patient age (year)	Days in treatment (days)	Fluoroscopy Time (min)	P_{KA} for all intervention and DynaCT (Gy cm ²)	P_{KL} for all CT-exams (mGy cm)
Mean±1 std	54±12	15±12	38±35	286±251	7269±5473
Median	55	12	27	178	4626
Min	20	3	5	45	1710
Max	78	89	171	1069	21316

Average P_{KA} corresponds to 2.4 endovascular coiling procedures
 Average P_{KL} corresponds to 7 head CT examinations.

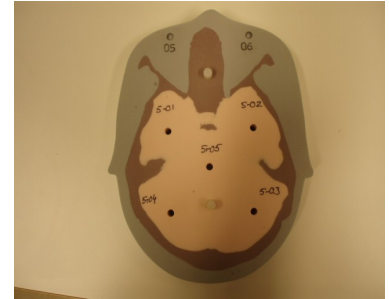
Maximum data correspond to 9 coiling and 20 head CT exams



Risk organ dose estimation H_T



Conversion factors H_T/P_{KL} and H_T/P_{KA} were determined from head phantom TLD-measurements.



Complemented with patient skin and eye dose measurements in coiling labb.

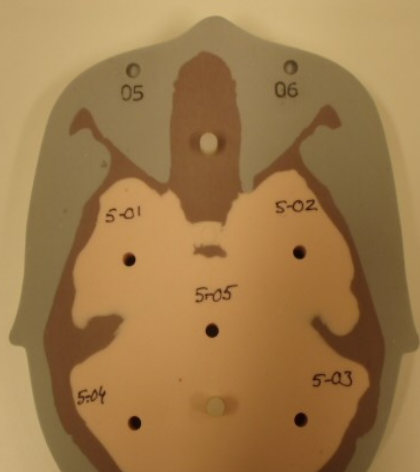


Individual patient's organ doses were estimated by

$$H_T = H_{T,CT}/P_{KL} \cdot P_{KL,pat} + H_{T,coil}/P_{KA} \cdot P_{KA,pat}$$

where individual $P_{KL,pat}$ and $P_{KA,pat}$ were collected from the hospital PACS/RIS data base

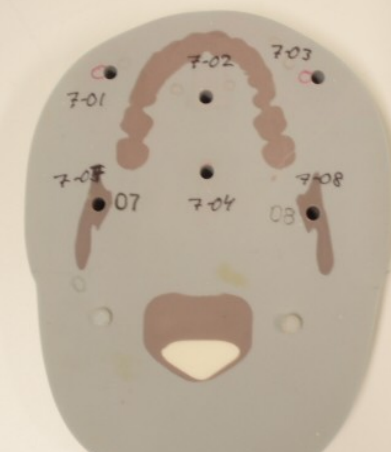




Brain and eye lens



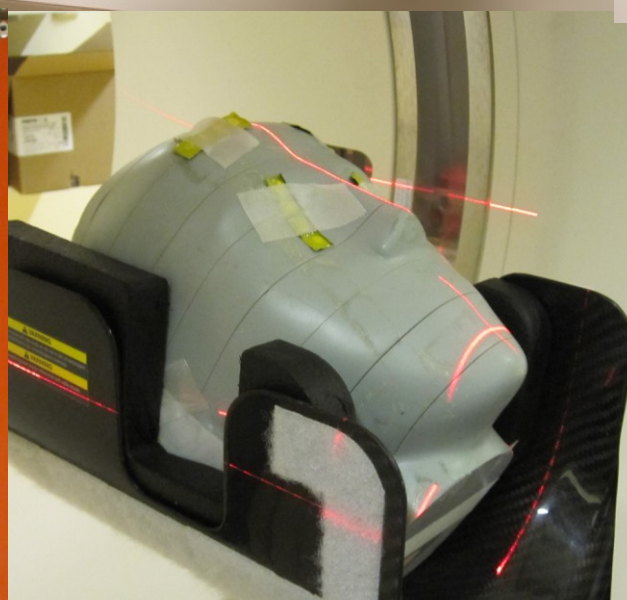
Salivary glands



Oral mucosa



Skin

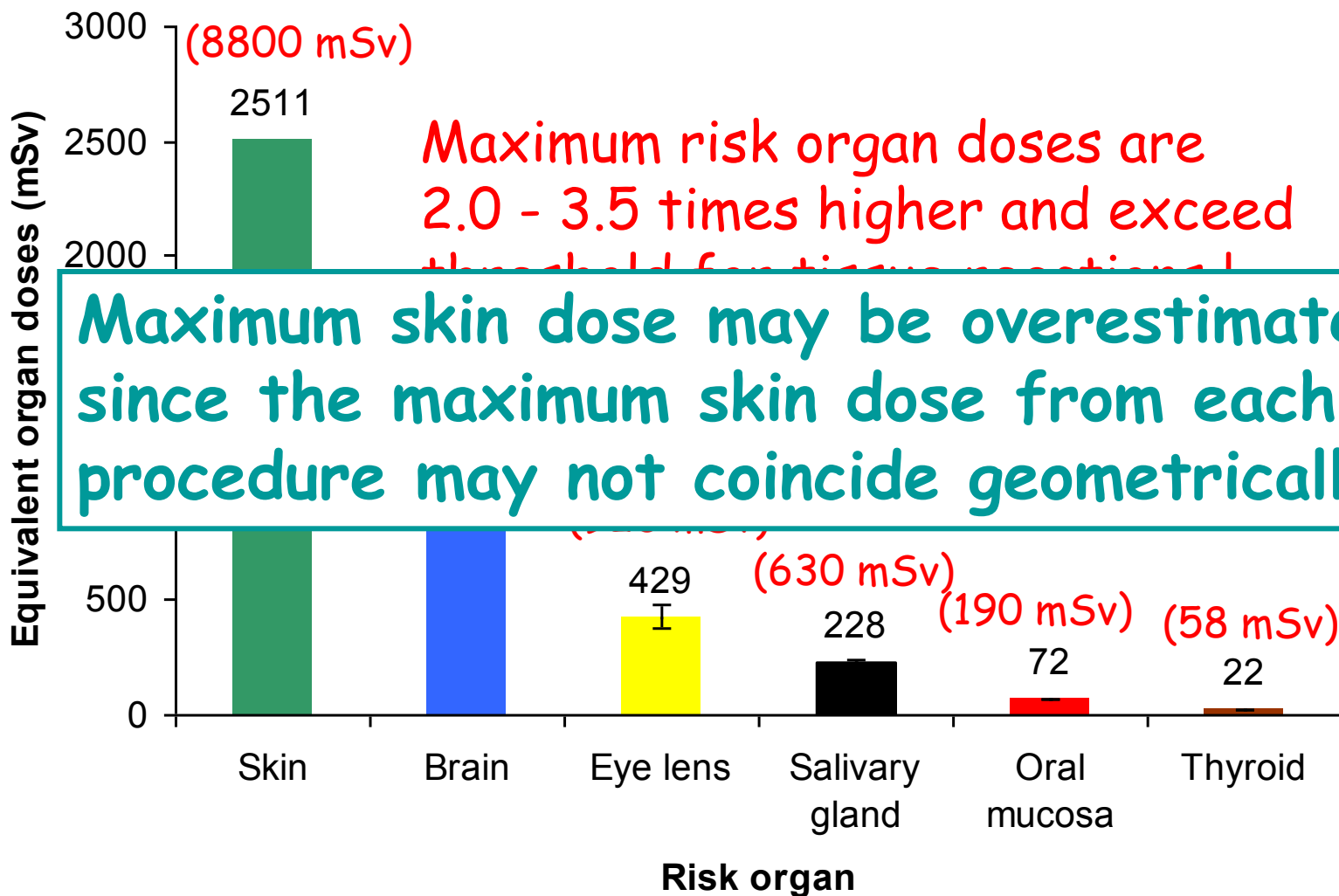


Anthropomorphic phantom in Mobile CT were imaged with the patient imaging protocols



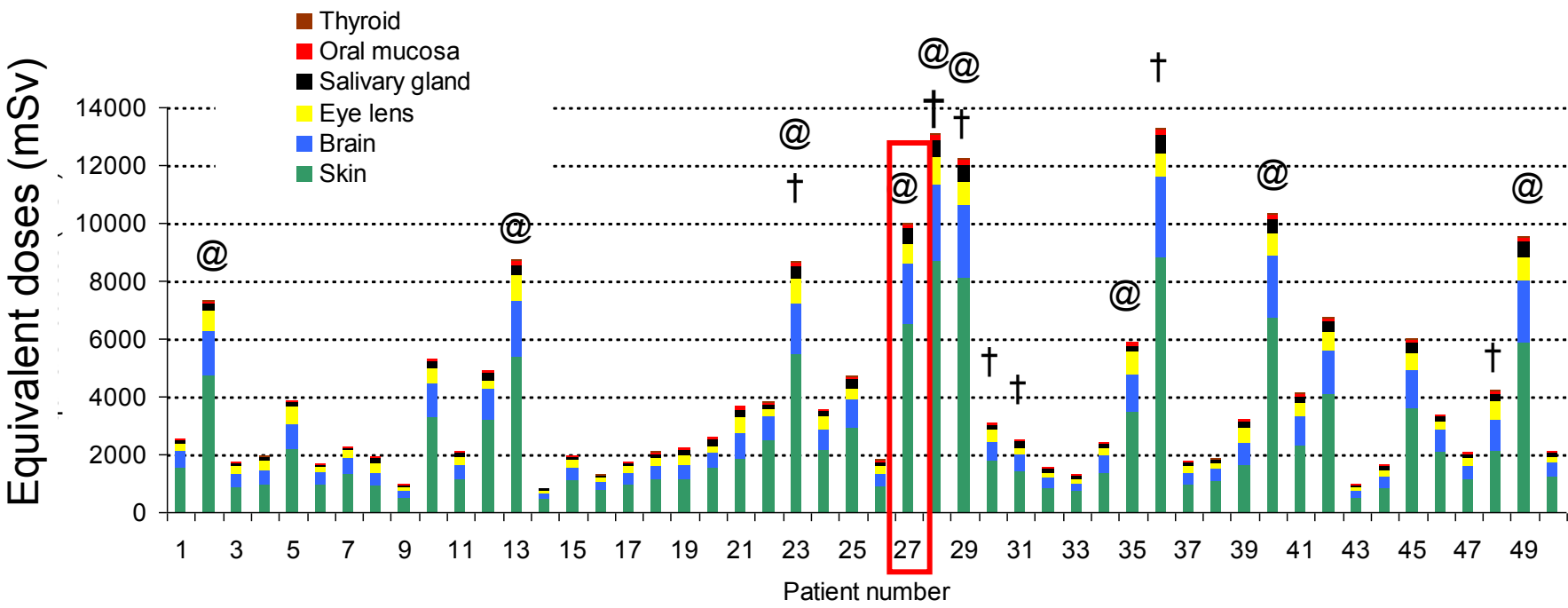


Result - mean organ doses





Individual patients organ doses



† : Patient died (GOS=5)
 @ : No of CT≥15

Most patient with $H_{T,skin} > 6$ Sv died from their decease and the rest were interviewed and one #27 experienced temporary epilation



Stochastic risks



Stochastic incidence risk for nervous system tumors is 0.004/Sv (Preston et al 2002).

Tumour types: Schwannoma 65%, Meningioma 20%, Glioma 10%, hypophysis tumors

Mean brain dose $H_{T,brain} = 0.92$ Sv.

Estimated risk of of nervous system tumors is about 0.4%, i.e. 4 cases per 1000 treatments but 90% are expected to be benign.

Conclusion: The risk for lethal cancer in nervous system is small in spite of high organ doses.





Tissue reactions



ICRP (2000, 2011) gives threshold for tissue reactions following high x-ray irradiations.

- Early temporary erythema (2.0 Sv) 21 cases exceeds threshold
- Late eye lens reaction (0.5 Sv) 18 cases exceeds threshold
- Temporary epilation (3.0 Sv) 14 cases exceeds threshold
- Skin erythema (6.0 Sv) 5 cases exceeds threshold
- Permanent epilation (7.0 Sv) 3 cases exceeds threshold

However 1 case of temporary epilation was found among patients with skin dose > 6 Sv.

Conclusion: Real risk of tissue reactions even if ALARA is applied and $DSD < DRN$.





Conclusions



1. The risk for SAH-survivors for tissue reactions are much larger than the risk for nervous system lethal cancer.
2. All surviving patients treated for aneurismal SAH should be informed of the potential risk of developing erythema and temporary epilation and checked for symptoms before discharged and at clinical follow-up.
3. Collaboration and data-exchange needed to better manage patient with high-dose therapy.

