

‘What the Eye Doesn’t See’: Radiation Dose Limits and the Lens of the Eye in Interventional Radiology and Cardiology

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Conflict of Interest

**No conflict of interest to disclose
with respect to this presentation**

Change in Dose Limit

- **In 2011, ICRP issued a statement regarding the lens of the eye:**
- **‘For occupational exposure in planned exposure situations, the Commission now recommends an equivalent dose limit for the lens of the eye of 20 mSv/year, averaged over defined periods of 5 years, with no single year exceeding 50 mSv.’**

Interventionalists

- **Medical workers perform complex fluoroscopically guided procedures in interventional radiology and cardiology**
- **They may receive some of the highest occupational exposures (scattered radiation)**
- **If appropriate protection is not worn, interventionalists could receive doses to the eye that exceed the new dose limit**

Protection vs Threat?

- **Ophthalmology studies have shown a 4-5x incidence of lens opacities in interventionalists vs controls (RELID study)**
- **Some operators, particularly those with a high case load, concerned the lower dose limit may constitute a possible threat to working medical practice**

Eye Lens Dose Interventionalists

Study	Country	Procedure	Average lens dose/procedure	Min/max lens dose/procedure	Dosemeter
O'Connor et al ¹¹	Ireland	ECRP		0.01/0.09 mSv	EYE-D™
Jacob et al ¹²	France	Various interventional cardiology		0.046/0.236 mSv	TLD
Vano et al ¹³	Spain	Catheterizations		0.044/0.067 mSv	APD
Al-Haj et al ¹⁴	Saudi Arabia	Cardiologists	0.02 mSv	0.005/0.08 mSv	TLD
Ainsbury et al ¹⁵	UK	Various radiologists	0.03–0.05 mSv		Eye lens
Romanova et al ¹⁶	Bulgaria	Fractura femoris	0.046 mSv	0.02/0.07 mSv	EDD30
		Fractura cruris	0.002 mSv (0.023 mSv with C-arm)	0.01/0.043 mSv	EDD30
Zagorska et al ¹⁷	Bulgaria	ECRP	0.034–0.093 mSv		EDD30
Rathmann et al ¹⁸	Germany	Radiologists	0.018 mSv	0.012/0.029 mSv	TLD
Khoury et al ¹⁹	Brazil A	Hepatic chemoembolization	0.017 mSv	0.007/0.041 mSv	TLD
	Brazil B	Hepatic chemoembolization	0.02 mSv	0.016/0.025 mSv	TLD
	Brazil C	Hepatic chemoembolization	0.08 mSv	0.012/0.148 mSv	TLD
Cemusova et al ²⁰	Czech Republic	Radiologists		0.013/0.070 mSv	EYE-D™

Barnard et al, BJR, 2016

Eye Lens Dose Interventionalists

- 3 large hospitals UK, cardiology procedures
- 61 participants, lead glasses worn by 9
- 2/61 projected eye dose close to 20 mSv

Ainsbury et al, J.Radiol.Prot, 2013

- 204 interventionalists, 8 hospitals
- 6 hospitals at least one member of staff who exceeded an equivalent of the 20 mSv dose

Martin et al, J.Radiol.Prot, 2013

Estimated Costs Implementation

• Additional lead glasses	£1,800,000
• Ceiling suspended lead shields	£1,600,000
• Raising awareness new limit	£164,500
• Revising risk assessments	£126,000
• Medicals for newly classified staff	£94,000
• Dosimetry service approvals	£49,000
Total approx.	£4 million

HSE, UK, 2013

Table 1: Cost Summary (£thousands)

	Minimum	Best Estimate	Maximum
COSTS - Medical Sector			
One-Off Costs - Medical Sector			
Revising risk assessments	£71	£127	£199
Mounted lead glass screens	£506	£1,609	£3,690
Additional lead glasses	£445	£1,789	£3,149
ADS approvals	£41	£49	£58
Raising awareness among workers	£190	£200	£211
Advising workers	£110	£164	£219
Initial medicals	£65	£94	£135
Total One-Off Costs - Medical Sector	£1,426	£4,032	£7,661
Ongoing Costs - Medical Sector (30 year present value)		=	
Health surveillance	£566	£759	£1,012
Dosimetry and record keeping	£465	£560	£663
Additional outside workers	£712	£1,001	£1,308
Investigating over-exposures	£781	£1,132	£1,574
Applying for five-year averaging	£681	£1,333	£1,985
Increased supervision, training and advice	£5,012	£5,404	£5,992
Replacing lead glasses	£1,605	£6,453	£11,358
Total Ongoing Costs - Medical sector	£9,822	£16,641	£23,892
TOTAL COSTS - Medical Sector (30 year present value)	£11,248	£20,673	£31,553

Ensuring Protection

- **Use protection equipment**
- **Comply with wearing dosemeters**
- **Important interventionalists receive regular and appropriate education and training in radiological protection**

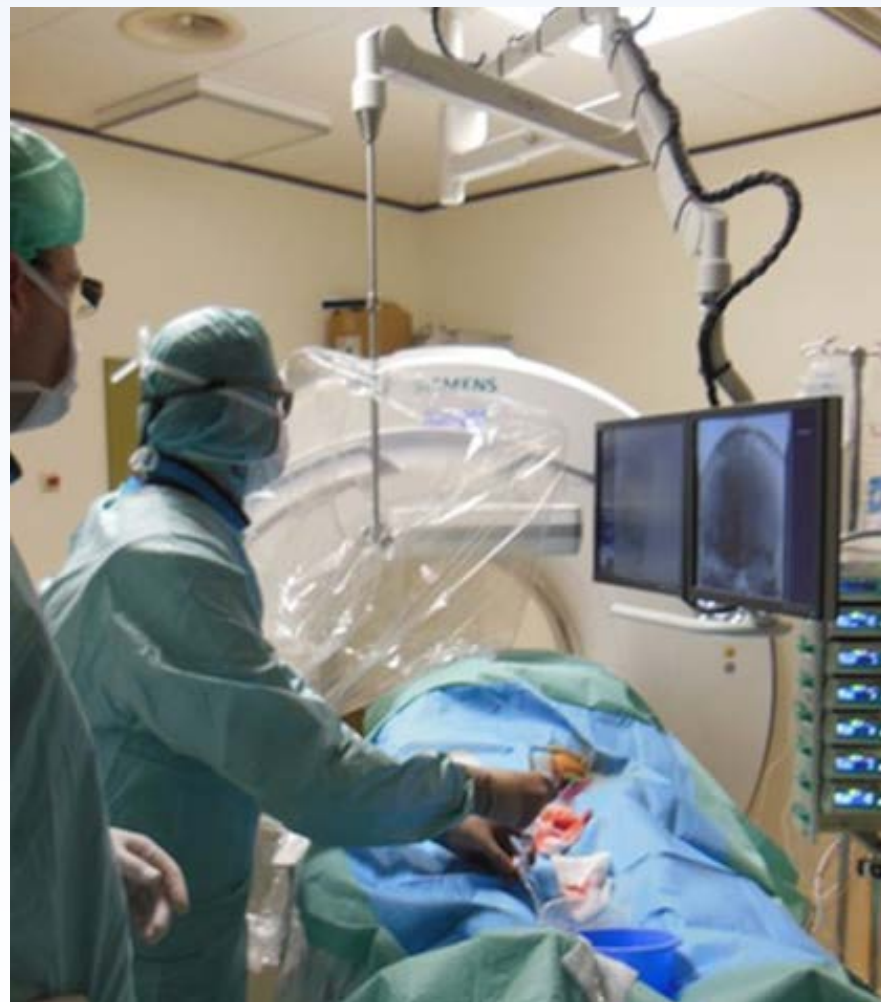
Protective Equipment

- **Ceiling suspended lead acrylic shields**
- **Protective eyewear**
- **Shielding pads and drapes**



Ceiling Suspended Shields

- Reported dose reduction factors typically 2-10
- Depends on effective positioning
- More difficult to use in lateral and oblique projections
- Require continual repositioning



Protective Eyewear

- Frontal protection, (0.75mm Pb, 65g)
- Frontal and side protection, (0.75mm Pb, 110g)
- My first lead glasses, >25 years ago, 75g



Protective Eyewear Issues

- **Weight and comfort of glasses**
- **Corrective prescription lenses**
- **Lens size and lead equivalence**
- **Close fit to facial contours important**
- **Conservative approach, dose reduction factor with glasses of 2**

Eye Lens Dosimetry

- **Eye doses can be assessed from a dosimeter placed over the lead apron at the collar or level of the neck**
- **Headband dosimeter with the sensor adjacent to the temple closest to the x-ray tube**
- **Dosimeter attached to the glasses**
- **Dosimeter inside the glasses (3 dosimeters)**
- **Compliance in the wearing of dosimeters important and needs to be practical**

Eye Lens Dosimetry

- New dosimeter developed and tested within the ORAMED project
- EYE-D™ monitors $H_p(3)$ – personal dose equivalent at a depth of 3mm



Radiation & Eye Lens: ORAMED

- **European study of interventional radiology and cardiology**
- **>1300 eye dose measurements**
- **Interventional radiology:**
 - **No protection 1%**
 - **Lead apron alone 12%**
 - **Lead apron + collar 62%**
 - **Apron, collar + lead glasses 25%**

Radiation & Eye Lens: ORAMED

- Highest eye lens doses for embolisations, 60 μ Sv/procedure
- In IR, eye lens doses reduced by:
 - Lead glasses factor 3 to 6
 - Ceiling shield factor 3 to 8 for embolisations

Annals of the ICRP

- **Pub 139: Occupational RP in Interventional Procedures**
- **Pub 121: RP in Paediatric Diagnostic and Interventional Radiology**
- **Pub 120: RP in Cardiology**
- **Pub 117: RP in Fluoroscopically Guided Procedures outside the Imaging Department**
- **Pub 113: Education and Training in RP for Diagnostic and Interventional Procedures**

Summary

- **Compliance of interventionalists with the revised ICRP dose limit for the lens of the eye should be possible if appropriate dosimetry and protection are applied**
- **This will require behavioural change and periodic education and training of medical workers**

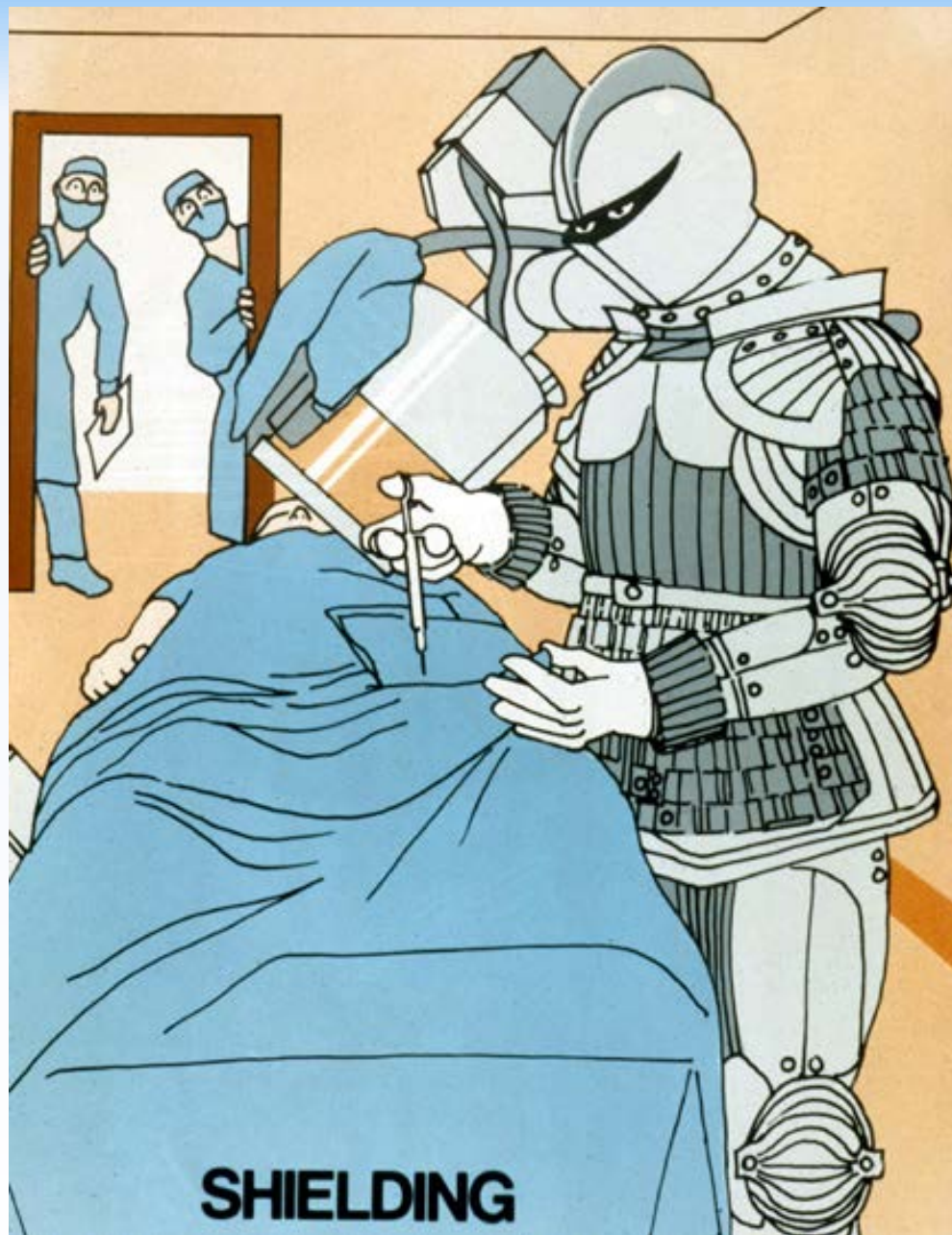
Summary

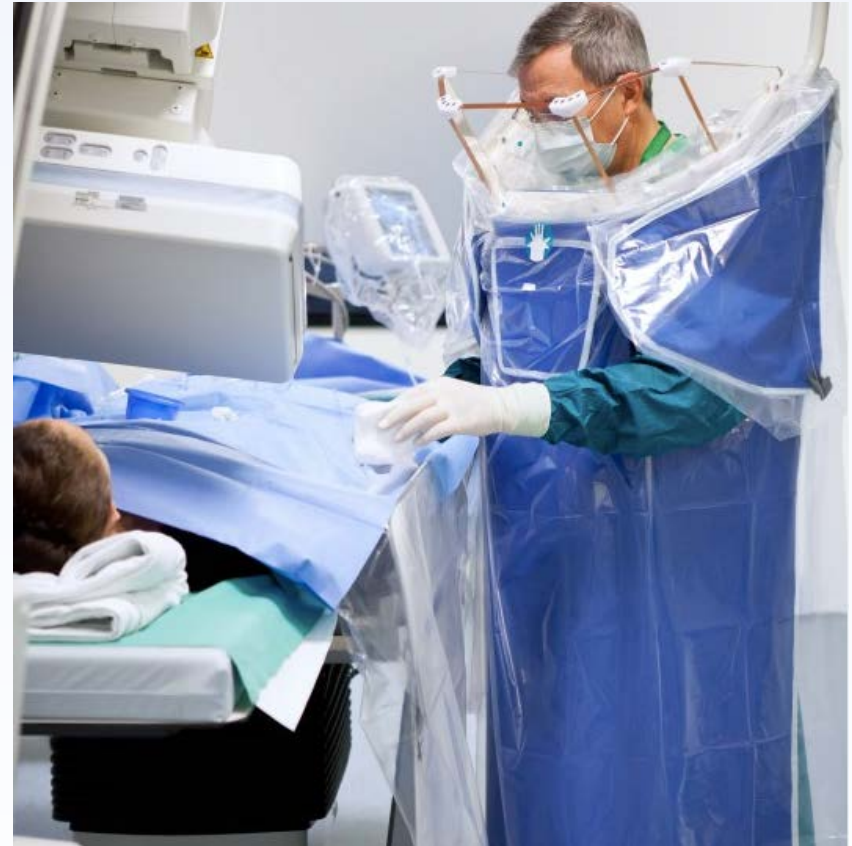
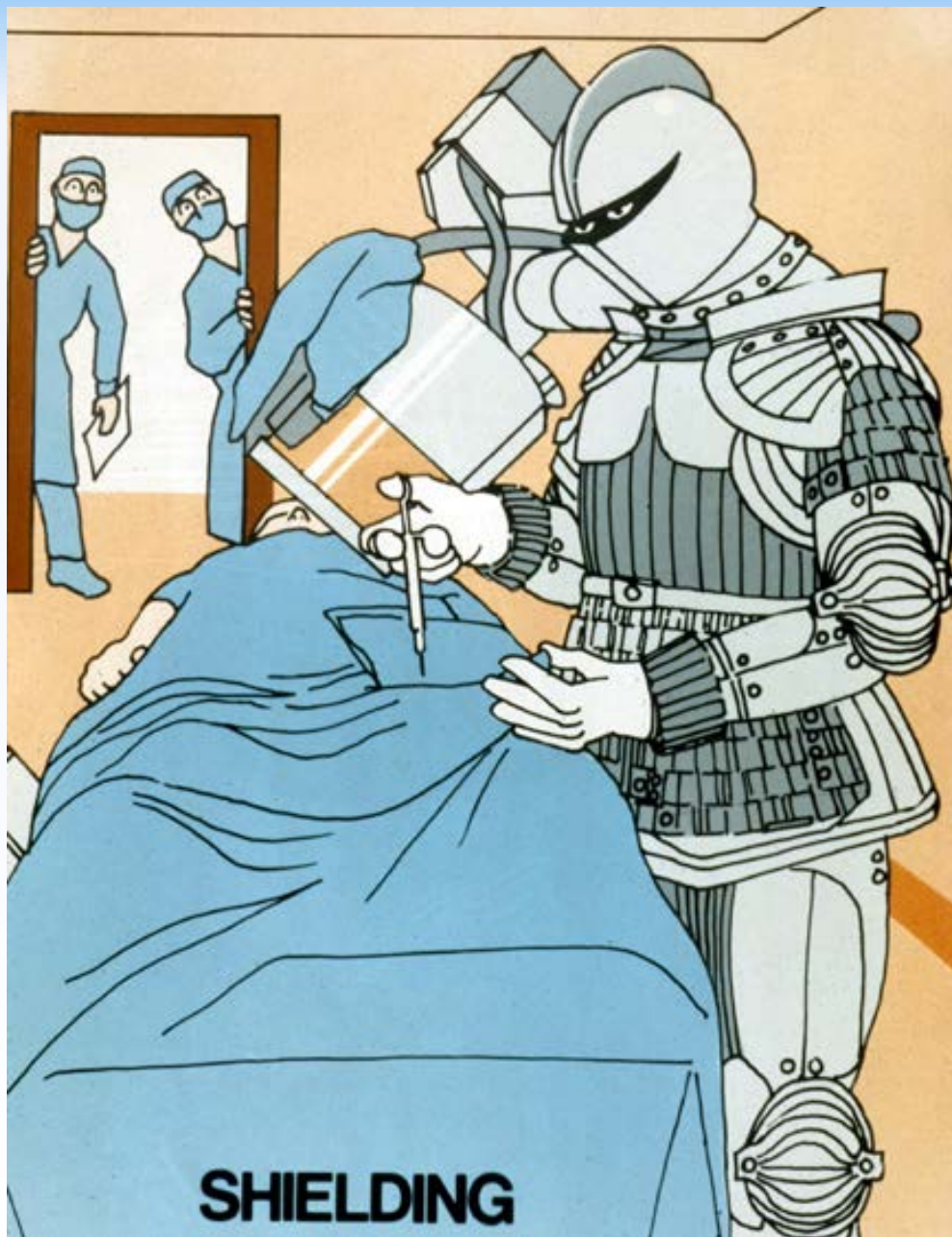
- **Eye lens dose monitoring techniques need to be refined and standardised to give accurate results**
- **Protective devices should be evaluated and designs both updated and improved to meet the needs of the future**
- **Protective devices should be worn for all procedures and good practices in the use of ionising radiation adopted**

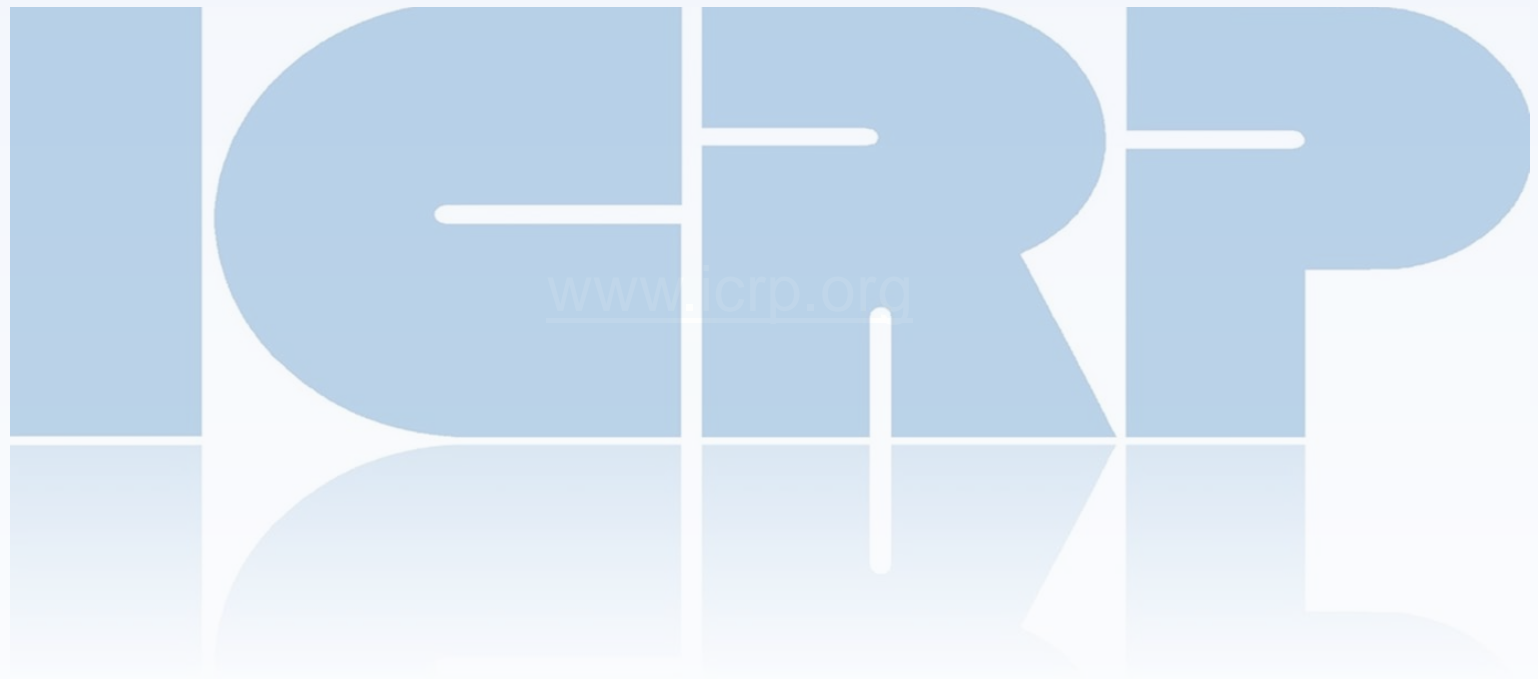
New Lens of Eye Dose Limit

Issue	Action
Reduction of lens dose limits	Monitor eye doses received over extended periods of time to evaluate impact
May impact working schedules	Increased use of protective dose-reduction measures should negate the need to reduce working hours
Effective monitoring of eye lens dose	Trained radiation-protection practitioners should advise
	Provide model for regular monitoring and record keeping
	Particular emphasis on workers routinely receiving >15 mSv in 1 year
Personal protective equipment	May require modification
	Thorough reassessment of appropriate PPE
	Must be worn effectively and routinely
Personnel training and awareness	Training to ensure workers are aware of the importance of protective lens (legal and health basis)
	Training regarding importance of protective eyewear and compliance of use
	Awareness of consequences of cataract development

Barnard et al, BJR, 2016







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