Videofluoroscopic Swallowing Studies

A web-based continuing education course prepared by:

Swallowing Rehabilitation Research Lab
www.steeleswallowinglab.ca

Radiation Safety & Patient Risk in Videofluoroscopic Swallowing Studies

LENGTH: 30 minutes

OVERVIEW:

Other modules have alluded to the risk related to contrast media that are used in videofluoroscopy, including the need for clinician awareness of patient allergies, dosage guidelines and contraindications, and food preparation safety. This module will specifically explore the question of radiation exposure and the risks involved. The main focus will be on patient risk, but considerations around clinician radiation exposure will also be addressed.

Learning Objectives:

At the end of this module, the clinician learner will be able to:

1) Explain the ALARA principle

2) Describe the main sources of radiation exposure in the environment

3) Identify the typical range of radiation exposure experienced by a patient in videofluoroscopy

4) List patient factors that may contribute to increased radiation exposure

5) Describe strategies a clinician can take to reduce their own exposure to radiation via scatter

6) Explain the impact of reduced pulse rates on radiation exposure and diagnostic accuracy

Overview: Radiation Safety & Patient Risk

- Overview of background radiation
- Harmful effects of ionizing radiation
- Recommended effective dose limits
- ALARA
- Source and path of radiation in VFSS
- Patient dose
- Clinician dose
- Special patient populations

Responsible Radiation Exposure

- The use of medical techniques using ionizing radiation must comply with the “As Low As Reasonably Achievable” (ALARA) principle.
- ALARA means minimizing all unnecessary exposure to radiation.
- “Unnecessary exposure” means exposure that does not contribute to improved diagnostic performance.
- Unnecessary radiation should be minimized because it may be associated with cancer risks without clear benefit to the patient.

Radiation Dose Units

- Sievert:
  - unit of radiation absorption
  - takes into account the relative biological effectiveness of different forms of ionizing radiation
- 1Sv = the amount of radiation roughly equivalent in biological effectiveness to 1 gray / 100 rads of gamma radiation
- Millisieverts are used in VFSS measurements
  - 1mSv or 0.001msv = 1/1000 of a Sv

https://www.britannica.com/technology/sievert

Responsible Radiation Exposure

- Videofluoroscopy (VF) involves low levels of radiation exposure, which carry risk of stochastic radiation effects.
  - Stochastic radiation effects are effects produced at random without a threshold dose level.
  - Their probability of occurrence is proportional to the dose but the severity is independent of it.
- In radiation safety, the main stochastic effects are carcinogenesis and genetic mutation (Blakely, 2000).

Ambient Radiation Exposure

- “Some foods such as bananas and Brazil nuts naturally contain higher levels of radiation. Brick and stone homes have higher radiation levels than homes made of other materials such as wood…. A lot of our exposure is due to radon, a gas from the Earth's crust that is present in the air we breathe.”

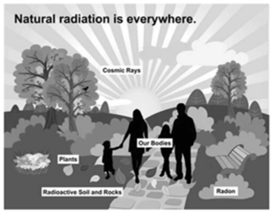
https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html

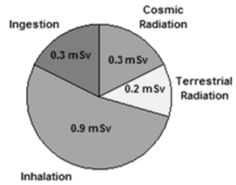
Ambient Radiation Exposure

- “Background levels can vary greatly from one location to the next. For example, Colorado, because of its altitude, has more cosmic radiation than the East or West Coast. It also has more terrestrial radiation from soils rich in naturally-occurring uranium. So people living in Colorado are exposed to more background radiation than residents of the coasts.”

https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html

Ambient Radiation Exposure





http://nuclearsafety.gc.ca/eng/resources/fact-sheets/natural-background-radiation.cfm

Ambient Radiation Exposure

"The data on links between radiation exposure and cancer are mostly based on populations receiving high level exposures… [e.g., survivors of the atomic bombs in Japan]….

Cancers associated with high-dose exposure (greater than 50,000 mrem, or 500 mSv—500 times the NRC limit to the public) include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma and stomach cancers."

https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html

Ambient Radiation Exposure

"The time between radiation exposure and the detection of cancer is known as the latent period. This period can be many years. It is often not possible to tell exactly what causes any cancer… chemical and physical hazards and lifestyle factors (e.g., smoking, alcohol consumption and diet) make a significant contribution to many of these same diseases… There are no data to establish a firm link between cancer and doses below about 10,000 mrem (100 mSv – 100 times the NRC limit).

https://www.nrc.gov/reading-rm/doc-collections/fact-sheets/bio-effects-radiation.html

Radiation Exposure Limits

Table 1

Maximum Effective Dose Limits for Ionizing Radiation

Person	Exposure Period	Effective Dose Limit (mSv)
Radiation worker	One year	50
	Rolling 5 calendar years	100
Pregnant radiation worker	Balance of pregnancy after informing employer in accordance with section 5(1)	4
Student undergoing a course of instruction involving the use of ionizing designated radiation equipment	One year	1
Person who is not a radiation worker	One year	1

https://work.alberta.ca/occupational-health-safety/radiation-legislation.html

How much radiation exposure does a patient receive in VFSS?

- Zammit-Maempel et al. (2007)
  - Mean exposure durations 181sec/3.02min (range 18-564 s)
  - Mean effective dose 0.2 mSv (range 0.01-1.4 mSv)
- Wright et al. (1998)
  - Mean exposure durations 286sec/4.77min (range 32–497 s)
  - Mean effective dose 0.4 mSv (range 0.03-1.1 mSv)
  - Comparisons: Chest X-ray (0.04 sV); Upper GI series (4.6 mSv); Barium enema (8.7 mSv).

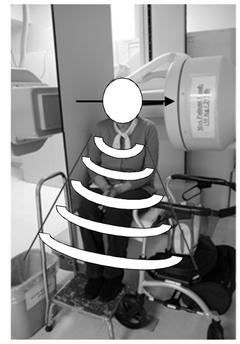
How much radiation exposure does a patient receive in VFSS?

- Moro & Cazzani (2006):
  - 1 m from the X-ray tube
  - 20-cm diameter FOV centred on the pharynx
  - median exposure duration of 149 seconds
    - first and third quartiles : 114 and 180 seconds
  - associated median effective dose of 0.35mSv
    - first and third quartiles : 0.26 and 0.46 mSv
- 180 seconds of radiation exposure involves a ~1/39,000 risk of an adverse event

Radiation Exposure

- Patient dose varies based on distance from the x-ray tube, according to the inverse squares law

Radiation Exposure



- Clinician exposure is highest immediately in front of the patient
- By stepping backwards and to the side, the clinician will dramatically reduce their exposure
- Any position 6 feet away from the source should be effectively a zero exposure location
- Wear protective aprons, dosimeters, and use shields

Radiation Exposure

- More experienced clinicians typically have lower average fluoroscopy times
- Standardized training in swallowing impairment and implementation of a standardized protocol can increase SLP confidence and efficiency

(Zarzour, Johnson, & Canon, 2018)

VFSS and Pregnancy

- Conducting VFSS during pregnancy is not contraindicated for the SLP
- Consult with your facility for specific guidelines

(Zarzour, Johnson, & Canon, 2018)

How much radiation exposure does a patient receive in VFSS?

- Bonilha, Humphries & Blair (2012)

Table 1 Average fluoroscopy times (min) and corresponding 95 % confidence intervals by diagnosis category

Diagnosis category	No. of patients	No. of swallow studies	Mean fluoroscopy time (min)	95 % CI
Neurology	179	212	3.1	(2.9, 3.2)
Pulmonary	78	94	3.0	(2.7, 3.2)
Cardiac	12	13	2.7	(2.3, 3.1)
ENT	217	280	2.8	(2.7, 3.0)
GI	43	47	2.7	(2.2, 3.1)
Other	83	93	2.7	(2.4, 3.0)
Total	612	739	2.9	(2.8, 3.0)

Pediatric Radiation Exposure

- A typical 20 cm field of view will capture a greater amount of an infant's anatomy
- The infant has a longer future lifespan ahead during which radiation effects can emerge
- Developing structures may be more radiosensitive
- Bolus path is shorter, takes less time
- Impact of lower image acquisition rates in terms of missing aspiration events may be greater
- ALARA especially important

Pediatric Radiation Exposure

- The anti-scatter grid should be removed for smaller patients because their smaller bodies do not generate enough scatter to significantly degrade the image, particularly when visualizing high-contrast objects, such as barium or iodinated media.
- Removing the grid allows the scatter to contribute to the required dose, thereby reducing the number of primary x-rays required by a factor of 2 or more, decreasing client dose.

(Hernanz-Schulman et al, 2010)

Pediatric Radiation Exposure

- Making it a common practice of removing the grid when it is not necessary can result in radiation dose reductions well over 50% without degrading image quality.

(Pike, 2014)

Radiation Exposure Considerations

- Is x-ray imaging necessary?
- Is the patient at particular risk related to radiation exposure?
- What can be done to limit exposure in this case?
  - Clear question
  - Standardized protocol
  - Collimated field of view
  - Adequate image acquisition rates
  - Pulsed vs continuous fluoroscopy

Key Messages

- VFSS involves low levels of radiation exposure, which carry risk of stochastic radiation effects - those produced at random without a threshold dose level.
- The main stochastic effects of radiation are carcinogenesis and genetic mutation.
- There are no data to establish a firm link between cancer and radiation doses below ~100mSv (100 times the NRC limit).
- Unnecessary radiation should be avoided (ALARA).

Key Messages

- All of us are exposed to ambient or background radiation on a daily basis, which varies by location (most notably with regards to proximity to the sun and soil composition).
- The four major sources of natural radiation are:
  - cosmic radiation
  - terrestrial radiation
  - inhalation/ingestion of naturally occurring radionuclides
  - medical procedures (approximately 1/3 of annual exposure)

Key Messages

- Estimates of patient exposure during VFSS vary widely, depending on:
  - longer exposure times
  - field of view
  - size of the patient
  - complexity of the patient
  - distance from the source of radiation, and
  - design of fluoroscopy equipment
- Moro and Cazzani (2006) found that the dose associated with a VFSS is 0.35 – 0.46mSv, with a risk of associated events assigned as 1 in 39,000 (“relatively low”).

Key Messages

- In Alberta, workers need to monitor personal exposure to ionizing radiation, and keep exposure under 50mSv per year and also under 100mSv over a rolling 5 year period.
- Tighter restrictions are placed on pregnant workers and trainees.

Key Messages

- Workers need to monitor personal exposure to ionizing radiation, and keep exposure under provincially mandated limits in mSv per year.
- Tighter restrictions are typically placed on pregnant workers and trainees.

Key Messages

- The primary source of radiation to the clinician conducting the VFSS is scatter from the patient.
- The further the clinician is from the source, the lower their dose; any position 6 ft away from the source should effectively be a zero exposure location.
- Good practice is to step backwards and to one side, and/or to use a screen to shield the clinician from the x-ray tube.

Key Messages

- In children:
  - the available future lifespan in which stochastic events may emerge is longer
  - there are more radiosensitive structures
  - the bolus travels a shorter distance from mouth to esophagus
  - the time available to observe an aspiration event is shorter
  - the relative loss in aspiration detection rates at lower pulse rates is greater than that seen with adults
- Collimation to limit the field of view to the oropharynx is particularly important.

Key Messages

- Patients with particular conditions and with more severe dysphagia are likely to need longer examinations and receive higher effective doses of videofluoroscopy.
- When another form of instrumentation can provide similar or equivalent information without involving radiation exposure, it is preferable.
- Using a tight, standardized protocol is critical.

Key Messages

- In order to observe the ALARA principle, the clinician must:
  - be certain VFSS is the best tool to answer the medical question at hand
  - consider risks related to radiation exposure that may be heightened with a particular patient
  - plan proactively and purposefully for opportunities to limit unnecessary radiation exposure

KNOWLEDGE CHECK

1. **True or false? There are no data to establish a firm link between cancer and doses below about 100mSv.**

   A True

   B False

2. **Which of the following is NOT one of the four major sources of natural radiation?**

   A Cosmic radiation

   B Terrestrial radiation

   C Microwave ovens

   D Inhalation of naturally occurring radionuclides

   E Medical procedures

3. **SLP confidence and efficiency can be increased by:**

   A undertaking standardized training in swallowing impairment

   B moving the patient closer to the source

   C decreasing the length of the VFSS exams

   D avoiding the use of a standardized protocol

4. **In order to observe the ALARA principle, the clinician must:**

   A be certain VFSS is the best tool to answer the medical question at hand

   B consider risks related to radiation exposure specific to each patient

   C plan proactively and purposefully for opportunities to limit unnecessary radiation exposure

   D all of the above

Answer key found on the following page.

KNOWLEDGE CHECK ANSWER KEY

1. A True
2. C Microwave ovens
3. A undertaking standardized training in swallowing impairment
4. D all of the above

EXPAND YOUR KNOWLEDGE

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