EXTRAVASATION AFFECTS QUALITY

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DISCLOSURES / RELATIONSHIPS

- Lucerno Dynamics
- Actinium Pharmaceuticals
- General Electric Healthcare
WHAT IS EXTRAVASATION?
WHAT IS EXTRAVASATION

*Accidental* administration of intravenously infused medications into the extravascular space around the infusion site, either by:

1. Leakage due to brittle veins
2. Previous venipuncture, or
3. Mis-positioned needles or IV catheters

**Word Origin** *noun*. 1670s, from Latin *extra* "outside" + form derived from *vas* "vessel."
EXTRAVASATION VS. INFILTRATION

*Infiltration* is the result of an extravasation,

It is the diffusion or accumulation of substance not normal to it in amounts in excess of the norm.
WHAT IS QUALITY

quality
/lˈkwɔːlɪdə/ noun

1. the standard of something as measured against other things of a similar kind; the degree of excellence of something.
QUALIFICATION OF A PET SCAN
VIA EYES

Relating to, measuring, or measured by the quality of something rather than its quantity.

How the pictures look.
QUANTIFICATION OF A PET SCAN
VIA STANDARDIZED UPTAKE VALUE

\[ \text{SUV} = \frac{\text{mean counts /pixel / sec} \times \text{calibration factor}}{\text{injected FDG dose (mCi) / body weight (kg)}} \]
QUANTIFICATION OF A PET SCAN
VIA STANDARDIZED UPTAKE VALUE

\[ \text{SUV} = \frac{\text{mean counts /pixel / sec} \times \text{calibration factor}}{\text{injected FDG dose (mCi)} / \text{body weight (kg)}} \]
WHAT IS QUALITY IN PET
the standard of something as measured against other things of a similar kind:

1. Accurate weight of the patient
2. Patient diet pre scan
3. Insulin level in body
4. Injection success
5. Incubation period activity
6. Uptake time
7. Bed time acquisition
8. Reconstruction parameters
9. Scanner/dose calibrator synchronization & calibration
10. Reading physician

\[ \text{SUV} = \frac{\text{mean counts /pixel / sec} \times \text{calibration factor}}{\text{injected FDG dose (mCi) / body weight (kg)}} \]
PET EXTRAVASATION CONSIDERATIONS

We conclude **dose extravasations were commonly encountered (10.5%)** in PET/CT. However, it is underreported by at least 31% due to omitting injection site from the FOV. When present, extravasations may lead to underestimation of SUVmax.

Osman, et al
Frontiers in Oncology

The quantitative evaluation of patient studies revealed that **paravenous injection is a relatively frequent effect (18%)** with a small fraction of patients presenting considerable extravasations ranging from 1% to a maximum of 22% of the injected dose.

Silva-Rodríguez, et al
Medical Physics
DO EXTRAVASATIONS MATTER?

Potential Implications

- Over staging cancer from false positives
- Under staging cancer from false negatives
- Therapy monitoring errors: incorrect SUV
- Therapy planning errors from incorrect threshold
- Myocardial perfusion misinterpretation
- FUO study: degraded diagnostic sensitivity
- Ambiguous results leading to repeat imaging
- Ambiguous results leading to invasive procedures

Source: David Townsend
Proper Technique for the insertion of an Intravenous Catheter

A. Insert the needle of choice bevel up at a 30-40 degree angle.

B. Advance the catheter to enter the vein until blood is seen in the flashback chamber. A steady backflow of blood indicates successful entry.

C. After the catheter tip and bevel are in the vein, advance the catheter forward off the needle and into the vein. Blood may ooze from the catheter indicating successful entry.

D. Dispose of the needle and connect the plastic cap to the catheter. Adjust flow rate as desired.
DIFFERENT WAYS TO INJECT

- Straight stick
- Butterfly
- Angiocath IV
- Medrad® Intego
- Rb82 auto-injector
LARA® - LUCERNO DYNAMICS (CARY, NC)

Lara® sensors and acquisition device

Injection Site

BGO Crystals

Lara® sensors in position on a patient
TIME ACTIVITY CURVE (TAC)
IDEAL INJECTION - L ANTECUBITAL FOSSA

TAC is indicative of an ideal injection. Bolus passes injection arm sensor. Counts drop to reference arm levels within 30 seconds.
NOT IDEAL INJECTION - L WRIST

TAC indicates some presence of radiotracer early in the uptake period. The curve is not indicative of an ideal injection.
MODERATE EXTRAVASATION - R ANTECUBITAL FOSSA

TAC indicates moderate presence of radiotracer during uptake period.

Pelvic Lesion SUVmean Understated by 20%
SIGNIFICANT EXTRAVASATION - R ANTECUBITAL FOSSA

TAC indicates significant presence of radiotracer during uptake period.

Lung Lesion SUVmean understated by 44%
MODERATE EXTRAVASATION – OUT OF FOV

TAC indicates moderate presence of radiotracer during uptake period. Injection arm counts approach reference arm counts by end of uptake period.

Right wrist injection. No image evidence of an infiltration.
MINOR EXTRAVASATION (STASIS) - L ANTECUBITAL FOSSA

TAC indicates minor presence of radiotracer during uptake period.
1. DOES IT FEEL GOOD TO KNOW?
2. CAN YOU AFFECT QUALITY?
## Results – Pooled Rate of Reduction (4 Centers)

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<thead>
<tr>
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<th>Phase 1</th>
<th>Phase 2</th>
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<tr>
<td><strong>Utilization</strong></td>
<td>Mean: 91%</td>
<td>Mean: 90%</td>
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<td></td>
<td>Range: 84-93%, Median: 93%</td>
<td>Range: 85-93%, Median: 91%</td>
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<tr>
<td><strong>Injections</strong></td>
<td>n = 1,331</td>
<td>n = 1,349</td>
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<tr>
<td></td>
<td>Mean: 333</td>
<td>Mean: 337</td>
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<tr>
<td><strong>Infiltrations</strong> (adjusted rate)</td>
<td>n = 119</td>
<td>n = 64</td>
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<td>8.9%</td>
<td>4.6%</td>
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Statistically significant reduction between phase 1 and phase 2 (4.3%, p<0.0001)
Three Technologists

Technologist Infiltration Rate Over Time

Source: Jackson Kiser
Variations leading to extravasation:

- Injection location
- Orientation (right or left)
- Needle gauge
- Patient age
- Patient BMI

Review of all potential co-variates showed:

- Non-antecubital fossa injections associated with infiltrations in all patients except 50 – 69y age group (p < 0.0001)

- Lower weight patients associated with more infiltrations (p < 0.003)
EXTRAVASATION IN CLINICAL PRACTICE

Pt being staged for lung cancer with PET-CT

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

Patient 1

Repeat PET/CT for lung cancer staging

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

Patient 1

Prostate uptake noted on second scan

Source: Jackson Kiser
Patient with a GYN malignancy, lesion in left pelvis that has reoccurred.

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

Patient 2

Axial PET (w/ extravasation)

Fused

Show uptake in left pelvic lesion with SUVmax = 5.6

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

Patient 2

Same patient without dose extravasation

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

Patient 2

Axial PET *(w/out extravasation)*  

Fused

Show uptake in left pelvic lesion with SUVmax = 7.1

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

SUV increase of 22% from the scan with extravasation.

Source: Jackson Kiser
EXTRAVASATION IN CLINICAL PRACTICE

Patient with Right AC extravasation, asked to return for repeat scan.

Lara® dose score was 483, which confirmed a minor extravasation.

SUV measurements were identical.

Source: Jackson Kiser
CONCLUSIONS

- Extravasations affect quality.
- Control the things you can control.
- Injection quality is important for successful evaluation of a PET study.
- Technologists can improve.
WHAT IS QUALITY IN PET

1. Accurate weight of the patient
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FUTURE CONSIDERATIONS

- What is the acceptable extravasation rate?
- Does PET quantification matter?
- What will we do with this information?
- Do extravasations change patient outcomes?
- What about Cardiac stress/rest injections (ratio)?
- Used to for measuring injection quality prior to therapy?
### Acknowledgements:

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<tr>
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<tr>
<td>Carilion Memorial Hospital</td>
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