Bile Acid Malabsorption Test

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Warning: The radiopharmaceutical ^{14}C taurocholic acid used in this protocol is not registered.

1. Introduction

The bile acid malabsorption test (SeHCAT test) evaluates the function of the terminal ileum. Orally administered radioactive bile acid mixes with the patient's bile acid pool and subsequently follows the enterohepatic cycle. Malabsorption in the terminal ileum results in decreased retention of labelled bile acid in the body and increased faecal excretion.
The most important radioactive bile acids used in this test are ^{14}C-taurocholic acid and ^{75}Se–taurocholic acid. Taurocholic acid is a stable bile-acid conjugate demonstrating little deconjugation (< 2% per day). The in-vivo retention of ^{75}Se taurocholic acid can be measured using a whole-body counter or a non-collimated gamma camera. In-vitro excretion is measured by analysis of faeces collected over a period of seven days (^{75}Se–taurocholic acid and ^{14}C-taurocholic acid). ^{75}Se taurocholic acid is a taurocholic-acid analogue with one Se atom inserted between the ^{23}C and ^{24}C atoms in the acid tail of the cholic acid molecule; hence the name homocholic acid; ^{14}C-taurocholic acid is a natural taurocholic acid with one ^{14}C atom substituted for the ^{24}C atom in the cholic acid molecule.

2. Methodology

This guideline is based on available scientific literature on the subject, the previous guideline (Aanbevelingen Nucleaire Geneeskunde 2007), international guidelines from EANM and/or SNMMI if available and applicable to the Dutch situation.

3. Indications

a. Quantification of the function of the terminal ileum in patients with postoperative choleric diarrhoea, after radiotherapy and in patients with severe infections or Crohn's disease.
b. Objectification of the need for cholestyramine therapy.
c. Accelerated intestinal transit e.g. after cholecystectomy or vagotomy.
d. Untraceable persistent diarrhoea.

4. Relation to other diagnostic procedures

a. This functional investigation cannot be replaced with any other examination. Vitamin B12 absorption also takes place in the ileum, but in another part and by different cells of the ileum.
b. The ^{14}C-cholylglycerin breath test delivers similar results. However, this test measures (decreased) absorption of bile acid and bacterial degradation at the same time. The SeHCAT test only measures bile acid absorption and is therefore more specific.
c. Morphological damage to the ileum can be diagnosed by CT, MRI or ultrasound, but this may not provide any functional information.

5. Medical information necessary for planning

a. Frequency and severity of diarrhoea.
b. Prior surgical interventions of the gastrointestinal tract, liver and/or pancreas.
c. Suspected Crohn's disease, ulcerative colitis, etc.
d. Prior therapy for diarrhoea.
e. Current therapy.

6. Radiopharmaceutical

Tracer:	^{75}Se-taurocholic acid (SeHCAT)
Nuclide:	Selenium-75
Activity:	370 kBq
Administration:	Oral (capsule) with water

7. Radiation safety

a. Pregnancy

The external radiation dose received by the foetus will be approximately 0,03-0,3 mGy (0,75 mGy/MBq). Thus, for this investigation foetal risk is very low. Nevertheless, the investigation should be postponed till after parturition whenever possible;

b. Lactation

Breast feeding should be interrupted for at least 3 weeks according to ICRP 106

c. Effective dose (mSv/MBq)

3,9; 2,0; 1,3; 0,86 and 0,69 for respectively a 1-yr, 5-yr, 10-yr, 15-yr old and an adult patient with a normal biological functioning.

8. Patient preparation/essentials for the procedure

Patient preparation

1. Patients must have fasted from 10:00 p.m. the day before.
2. Cholestyramine medication should be discontinued at least three days before the investigation.
3. Duration of the investigation: several days to one week. Each measurement takes approximately 10 min.

Essentials for the procedure

Possibly a plumb line (e.g. a thin chain) or a ruler to position the patient under the gamma camera. Tegaderm for taping the skin markings.

9. Acquisition and processing

Camera method for retention measurements

1. Oral administration of the labelled ^{75}Se-taurocholic acid in the morning with water (15 ml before, 15 ml together with the capsule and 15 ml after the ingestion of the capsule). Ask the patient to try not to defecate between the administration and the first measurement (3 h post ingestion).
2. Three hours after administration, the first measurement is taken using the non-collimated gamma camera (100% value). Another measurement can be taken as late as possible on the same day. Subsequent measurements are taken once daily. Record the time at which each measurement is taken. The measurements

are continued until the counts fall below 1/3 of the initial measurement, or until one week has passed. If evaluation of the 7-day retention is preferred, then measurements are only taken after 3 h and after one week.

3. Make sure that the background activity is as low as possible for each measurement: remove radioactive sources from the measuring room and keep all radioactive patients at an appropriate distance (depending on the degree of shielding provided by the walls). In order to calculate the geometric mean, measurements are taken from anterior and posterior. Make sure that the patient lies in the same position for each measurement and that the gamma camera and the examination table have been adjusted to the setting they were in for the first measurement. The midpoint between the navel and the xiphoid process should be positioned in the centre of the gamma camera. The centre of the detector is marked on the skin and is taped using Tegaderm.
4. The distance between the gamma camera and the patient should be as large as possible; preferably > 40 cm to maximise the field of view of the gamma camera and to prevent geometric problems in the follow-up measurements. The standard and background are measured in the same position.
5. Measuring the standard is not strictly necessary, but provides insight into the variation in the counting statistics. This standard should have approximately the same volume as the abdomen and should contain 300-400 kBq ^{75}Se. E.g. fill a bucket with water, add a pack of wallpaper paste and mix with the ^{75}Se and a bacteriostatic agent (e.g. thimerosal, sodium azide or similar), then seal with a lid. Measure this standard before each measurement on the patient.
6. Data processing: the number of counts in the patient, the standard (if applicable) and the background are presented in a table stating the date and time of each measurement. After completion of the investigation, the net number of counts (corrected for physical decay, background counts and any abnormal counts produced by the standard) are used to calculate the half-life. This can also be determined graphically on semi-logarithmic paper. The curve can be used to determine the 7-day retention and the loss per cycle (there are five cycles per day, therefore determine the percentage loss after 0,2 days). If the 7-day method is chosen, then the percentage retention is calculated after one week only.

Measurement of excretion via the faeces

1. Prior to ingestion, the capsule should be measured under the gamma camera in a phantom (e.g. the bucket described above). This must be done under the same conditions as will be used for the patient and the faeces.
2. All faeces is collected, in 24 h portions. This starts immediately after administration of the ^{75}Se-taurocholic acid capsule and is continued for 5 days.
3. Data recording: collected counts per measurement are recorded and the percentage of the administered dose is calculated per 24-h portion (corrected for physical decay and background activity). The total is compared to the whole body retention values.

Camera settings and processing

Energy:	^{75}Se settings, 280 keV with a 20% window
Window:	See above

Collimator: None, although shielding the outer edge of the crystal with a lead ring is advisable

Counting time: The counting time is 5 min per view (anterior and posterior abdomen); the background and the standard are also counted for 5 min. Geometric means are calculated. The excretion measurements also use counting times of 5 min for the faeces and the standard. Digital systems require images to be made; these show the counts collected.

Computer: Matrix 128×128×16

10. Interpretation

a. Although patients with severe bile acid malabsorption will demonstrate rapid loss, a lag phase may occur in patients with combined pathology (intestinal inflammation, pancreatic dysfunction, etc) or in patients with less severe malabsorption. SeHCAT excretion from the body then only starts after several measurements. This should be taken into account when the half-life is determined.

b. Jumps can occur in the curves of post-vagotomy patients. Such patients show slow loss, but retention suddenly decreases very strongly after one measurement. These patients do not have diarrhoea as a result of bile acid malabsorption, but bile acid malabsorption due to very rapid ileal passage, which causes diarrhoea in the colon.

c. The spread in standard values is caused by the difference in bile acid pool sizes between patients; this is also particularly important for the evaluation of choleric diarrhoea. SeHCAT is a marker for the entire bile acid pool; choleric diarrhoea, however, is caused by dihydroxy bile acids (deoxy and chenodeoxycholic acid). The composition of the bile acid pool is subject to change; the proportion of dihydroxy bile acids may be high to an extent that these bile acids cause diarrhoea, without clearly increased SeHCAT loss.

11. Report

a. The dose, the measuring method followed and the half-life found (or 7-day retention) are stated in the report. The loss per cycle is calculated from the half-life (5 cycles per day); this is an excellent parameter to demonstrate the severity of the malabsorption.

b. Reference values:

Half-life:	Normal > 3 days, pathological < 2,5 days
Loss per cycle:	Normal < 5% per cycle
7-day retention:	20%, pathological < 10%. Of note, to correct for radioactive decay, measured values after 1 week should be multiplied by a factor 1,04

12. Literature

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