Efficacy of a Double-well Single-plastic Scintillation Counter for Surveying Sentinel Lymph Nodes in Gastrointestinal Cancer

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Since 2000, our department has been calculating the percent injected dose (%ID; the accumulation ratio of an injected amount) in isolated lymph nodes when detecting sentinel node navigation surgery for upper gastrointestinal tract cancers. However, the conventional procedure of calculating %ID is complicated. In this study, we used DCM-200 (Aloka Co., Tokyo, Japan). This is equipped with two wells, one to receive a syringe to measure high-level radioactivity and one for insertion of a tube to measure low-level radioactivity. We compared results using the conventional autowell method and the DCM method. (Subjects and Methods) Ten patients with T1N0 gastric cancer underwent SNNS using the RI method. The radioactivity of 54 lymph nodes was measured using both a well-type scintillation counter ARC-300 and the DCM-200. Each gross count and %ID, which was obtained using the conventional calculation method and the DCM-200 method, were compared. (Results) The gross counts among the instruments showed a high correlation (r=0.960). The calculated %ID showed a high correlation, with the value found by the DCM-200, being approximately 1.5 times higher than that found using the conventional calculation method. (Conclusion) The DCM-200 allowed both the administered amount and the amount found in the isolated lymph node to be measured with high sensitivity. Correction for radioactive decay as a factor of time is performed automatically, so that both conversion between instruments and correction for decay over time can be omitted, resulting in a simple calculation process.

Key Words: sentinel node navigation surgery, percent injected dose (%ID), double well scintillation counter

Introduction

Recently, the use of sentinel node navigation surgery (SNNS) in various organs has become increasingly common. Since 2000, our department has been calculating the percent injected dose (%ID; the accumulation ratio of an injected amount) in isolated lymph nodes when detecting SNNS for upper gastrointestinal tract cancers. The Standard Technique Protocol Committee of the SNNS Study Group recommends the calculation of %ID in isolated lymph nodes to determine the sentinel nodes. This treatment protocol is currently not widely used due to differences in the post-operative
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handling of specimens, using techniques such as RT-PCR, for example, in addition to the complexity of the %ID calculation.

In this study, we used DCM-200 (Aloka Co., Tokyo, Japan) (Fig. 1). This is equipped with the two wells, one to receive a syringe to measure high-level radioactivity, and one for insertion of a tube to measure low-level radioactivity. This is intended to facilitate the calculation of the %ID of the sentinel lymph node and analysis of the results. We compared results using the conventional autowell method and the DCM-200 method.

**Subjects and Methods**

We performed sentinel lymph node identification and documentation using a radioisotope (RI) method in 10 patients with cT1N0 gastric cancer. $^{99m}$Tc-phytate or $^{99m}$Tc-Sn colloid was endoscopically injected submucosally into 4 sites around the tumor before surgery. Amounts injected were adjusted to yield a radioactivity level of 11.1 MBq (0.3 mCi) by the time of surgery.

In addition to the primary lesion a total of 54 lymph nodes were resected. After surgery, both a gamma probe autowell scintillation counter and the DCM-200 were used to measure radioactivity in each of the 54 isolated lymph nodes. Each gross count and %ID obtained using the conventional calculation method, was compared with that measured by the DCM-200. We used the NAVIGATOR GPS gamma probe (Autosuture, Tokyo, Japan) and the ARC-300 autowell (Aloka Co., Tokyo, Japan) for conventional measurements.

**Overview of the DCM-200**

In the double well DCM-200 described above, a cylindrical plastic scintillator is used as a detector, but only in the tube well. For high-level radioactivity measurements, the detector is kept at a distance with a collimator from the syringe so that a wide range of radioactivity levels can be detected, i.e. a sample with high-level radioactivity is measured with the aforementioned scintillation counter via a housed collimator, allowing measurement of a wide range of radioactivity levels. The low-and high-level radioactivity measures have ranges of
148Bq–0.74 MBq (0.004µCi–20µCi) and 0.148 MBq–740 MBq (4µCi–20mCi), respectively; there is a 1000-fold difference in the dynamic range between the two wells. This large difference is critical for the inspection of sentinel lymph nodes, related to tumors found in various organs. The tube well section of the DCM-200 also houses an electronic balance used to measure the sample weight. In addition to 99mTc, a total of 17 different isotopic nuclei can be measured.

%ID Calculation Method

Conventional Procedure (Fig. 2)
1) Two syringes with equal amounts of radioactive material, as determined by a survey meter (CurieMeter), were prepared.
2) One of the syringes was then used to inject patient.
3) The other syringe was diluted to 1/1,000, 1/10,000 and 1/100,000 for storage and used as a diluted standard solution to measure radioactive decay.
4) A gamma probe was used during surgery to identify targets lymph nodes, which were isolated to allow repeated radioactivity measurements at the backtable.
5) Radioactivity within the isolated lymph node and in the diluted standard solution described above were also measured simultaneously with an autowell in order to calculate the %ID.

DCM Method (Fig. 3)
1) The radioactivity of the material in the syringe used for administration was measured in the DCM-200 well used for measuring high-level radioactivity.
2) A gamma probe was used intraoperatively to identify the lymph nodes, which were isolated to allow repeated radioactivity measurements.
3) The postoperative radioactivity of isolated lymph nodes was measured with the DCM-200 tube well used for measuring low-level radioactivity. By setting the DCM-200 appropriately, it automatically times the series of experimental procedures and simultaneous measurement of decayed and corrected radioactivity levels and radioactivity levels of the material in the syringe used for administration, thereby allowing direct calculation of the %ID.

Results
a) Comparison of Counts from Each Instrument
Counts from the isolated lymph nodes obtained by the autowell and by the DCM-200
showed a high correlation (r=0.960) (Fig. 4). However, comparisons between the gamma probe and the autowell (Fig. 5) and between the gamma probe and the DCM-200 (Fig. 6) showed non-significant correlations of r=0.654 and r=0.558, respectively.

b) Comparison of the %ID obtained by the conventional calculation method and the DCM-200.

The %ID of isolated lymph nodes calculated using both methods showed a high correlation (r=0.974) (Fig. 7). As shown in the correlation equation, the DCM-200 yielded a %ID value that is approximately 1.5 times higher than that obtained with the conventional calculation method.

Discussion

We set out to determine whether the more convenient and time-efficient DCM-200 would yield results as accurate as the conventional autowell method for measurement of %ID. While the RI method is superior to the dye-labeling method for evaluation of lymph nodes, this method is not satisfactory in several aspects.

First of all, the accuracy of the gamma probe is poor, because it is difficult to align and it also has poor sensitivity. During use, the direction of the probe greatly affects the count obtained. Moreover the inflexibility of the probe, due to its fixed shaft, can increase error rate. When performing an interperitoneal operation, ray scattering from the primary lesion make it difficult to confirm the accumulation of counts of radioactive emissions using the probe. Accumulations of counts in the liver and in the intestinal tract are also difficult to accurately detect using the probe. The poor sensitivity of the probe also means that the lymph nodes are not detected when the accumulated counts are too low.
Moreover, counts measured at the time of preoperative administration of radioactive material and counts measured later can vary in magnitude. This results in comparisons between the gross counts alone, which can lead to inaccurate estimates, not only between facilities, but also within the same facility. Hence, count standardization is difficult, and for proper quantification a collaborative study between multiple facilities and simultaneous use of the %ID has been recommended by the SNNS Study Group.

We measured high-level radioactivity material administered for patients using the Curie Meter and low-level radioactivity in isolated lymph nodes using the autowell. We stored and diluted identical samples to those administered to convert and correct for decay of the measured values between the instruments. However, this is a complicated procedure and may result in inaccurate estimates.

The difference in the amount of radioactive material that migrates into other tissues and the amount administered in the lymph node has been shown to be within the range of 1/100 to 1/10,000. The DCM-200 allows both the administered amount and the amount found in the isolated lymph node to be measured with high sensitivity. Correction for radioactive decay as a factor of time, which is one of the problems found in the calculation of the %ID, is performed automatically, so that both conversion between instruments and correction for decay over time can be omitted, resulting in a simple calculation process.

Comparison of the gross counts among the instruments showed that the correlation between the low-level radiation dosage well of the DCM-200 and the autowell is excellent (r = 0.974). Linearity in the low-level radioactivity range is also excellent. On the other hand, the gamma probe has a slightly lower linearity in the low-level radioactivity range. This may be due to the low sensitivity of the probe and to the lack of flexibility in the direction of the detector, suggesting the possibility of inaccurate estimates of sentinel lymph nodes using the gamma probe alone intraoperatively.

A comparison of the %ID calculated using the conventional method and that found using the DCM-200 shows that the latter gives a %ID value that is approximately 1.5 times higher than that calculated using the conventional method. This difference may result from instrument incompatibility, counting loss, or from overestimation in the high-level radioactivity well in the DCM-200. However, with the DCM-200, counting loss of the administered amount of RI is unlikely, because the maximum amount administered is in the range of 2.4-4.8 mCi, as administration before SNNS is adjusted to yield an intraoperative RI radioactivity level of 0.3mCi. On the other hand, high-level radioactivity measured by the DCM-200 was shown to be approximately 90% of the value determined by the Curie Meter, suggesting that poor compatibility between the two instruments is the more likely cause of a higher %ID determined by the DCM-200. Itoh et al. standardized the counting efficiency of the tube well and syringe well to approximately 8% and 0.01%, respectively, using $^{99m}$Tc. They reported that the counting efficiency of the tube well is less affected when a fluid quantity of 1-4 ml is used, whereas the efficiency of the syringe well varies slightly, suggesting the collimation procedure could after the measurement. This indicates the need for further studies of the amount of liquid administered as well as studies of the syringe geometry.

On the other hand, in the method used in the present study, other factors, such as dilution, correction for decay, and conversion of the measured values between the autowell and the
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Curie Meter, may have contributed to the discrepancy. However, this discrepancy is not believed to be due to a procedural error, as both methods show strong correlation of the %ID. Further studies are needed to address this issue as well as to review the cut-off value for a hot node.

Conclusion

DCM-200, which is a well scintillation counter equipped with two detectors, was used to calculate the %ID in the sentinel lymph node survey. The %ID calculation for isolated lymph nodes is simpler when using the DCM-200, compared with the conventional calculation method. Most of all, the omission of the dilution made the survey more convenient and accurate. The calculated %ID shows a high correlation with that found using the conventional calculation method, with the value found by the DCM-200 being approximately 1.5 times higher than that found using the conventional calculation method. Further studies are needed to confirm the suitability of the methods used as well as to review the cut-off value for a hot node.

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References