Introduction
All current imaging modalities have shortcomings in identifying and staging gastric tumors. Advances in MR technology have made this modality more promising for imaging gastric tumors. Advances in fast imaging technique have allowed MR imaging to produce a dynamic scan with quality identical to that of CT scan [1]. Subtraction images can decrease the signal intensities of perigastric fatty tissue, and these images might be able to show the three-layered pattern of the normal gastric wall. Also, MR examination is operator-independent and can be used to evaluate hepatic and lymph node metastasis and peritoneal dissemination as well as the gastric tumor itself. We therefore decided to test the usefulness of MR imaging in detecting gastric tumors and staging gastric cancers.

Materials and Methods
Patients
39 patients with gastric lesions (mean age, 54 years; range, 23-82 years). Thirty of these patients later had subtotal or total gastrectomy and their surgical specimens were compared with the MR images. Another 8 had biopsy specimens because of unresectable carcinomas (5 patients), malignant lymphomas (2 patients), and an advanced malignant stromal tumor (1 patient). The remaining patient was determined to have gastric intramural splenosis proved by the radionuclide imaging study and did not receive any operation.

Imaging Technique
The patients fasted at least 4 hours and drank 250-400 mL of fluid before the MR study. Care was taken not to overdistract the stomach, so as not to distort the shape of the gastric tumor. Scopolamine 20 mg (Buscopan; Boehringer International, Ingelheim, Germany) was administered intramuscularly to decrease the peristalsis of stomach and bowel loops. The patients were placed in either the supine or prone position, whichever placed the lesion in contact with the ingested fluid. The MRI was performed on a 1.5 T Gyroscan ACS-NT MR system (Philips Medical Systems, Best, the Netherlands). Axial T1-weighted turbo-field-echo (15/4.1[repetition time msec/echo time msec]; 23 factors, 4 signals acquired) and T2-weighted turbo-spin-echo (2000/100[TR/TE]; 25 flip angle, 4 signals acquired) images were obtained before, immediately after, 14 seconds, 40 seconds and 2 minutes after intravenous bolus contrast injection.

Image Analysis
Focal thickening and/or focal abnormal enhancement of gastric wall were regarded as lesions. The depth of gastric carcinoma penetration was determined as T1, T2, T3 and T4 cancer.

MR-Pathologic Correlation
The 30 gastrectomy specimens were cut in planes corresponding to the imaging planes at MRI. The histologic section was then compared with the MR imaging section. The degree of serosal invasion was evaluated by a pathologist (K.B.T.) and staged according to the T factor of the TNM classification [2].

Results
Sensitivity and Contrast Enhancement of Gastric Tumors
The sensitivity for gastric lesions was 100% (39 of 39). All these tumors were enhanced in the dynamic and delayed enhanced MR images. A noticeable strong enhancement of advanced cancer was often seen from the inner side to the outer. Gastric carcinomas (33 patients) showed stronger enhancement than did the other gastric tumors except for intramural splenosis, which appeared as significantly enhanced foci.

T-Staging of Gastric Carcinomas
One gastric polyp with malignant foci confined in the enhanced mucosal layer on the dynamic MR imaging was judged to be a T1 tumor. Of the five tumors shown to be T2 in pathology, 4 were judged to be T2 in the MR images because the entire gastric wall was involved and the outer enhanced muscular-serosal layer remained intact. The remaining one was diagnosed as T3 because the carcinoma within prominent lymphoid stroma made a nodular outer border, but didn't penetrate the serosa in pathology. Diagnosis of T2 cancer was therefore correct in 4 of 5 (80%) lesions. Two of the 22 p-T3 cancers were understaged as T2 because small extraserosal extensions of the tumors were obscured by the perigastric fat. Another p-T3 tumor was overstaged as T4 because the enhanced lesion had touched the strongly enhanced spleen. All five p-T4 lesions were considered T4 tumors by dynamic subtraction and delayed enhanced MR images. The overall accuracy of dynamic subtraction and delayed enhanced MR images in determining the T staging was 88% (29/33 tumors).

Discussion
All the gastric carcinomas showed clear early enhancement on dynamic subtraction MR imaging. Advanced gastric cancers are gradually enhanced from the inner mucosal side to the outer serosal side and the entire tumor is depicted most clearly on the delayed images. The detectability of the gastric tumors by MR imaging is strongly influenced by size. We included no patients with flat- or depressed-type early cancers in our study. One of the reasons was that the spatial resolution of MR would prohibit it from detecting early cancers. The low detectability of early cancers limits the use of MR.

Conclusion
Gastric carcinomas are strongly enhanced during the early phase through delayed phase of enhanced images. The destruction of the multi-layered pattern and the depth of tumor invasion on MRI made it possible to accurately detect the location, gross appearance, and degree of serosal invasion of tumors in about 88% of the cases.

References