Validation of Software Assisted Small Bowel Motility Analysis

M. A. Patak[1], S. Raible[2], Z. Szuecs-Farkas[1], R. Cattin[2], H. Bouquet[3], U. Bill[3], J. Steinhauser[1], P. Vock[1], and J. M. Froehlich[1]
[1]Institute of Diagnostic, Interventional and Pediatric Radiology, Inselspital, University Hospital, Bern, BE, Switzerland, [2]Virtual Perception Group, University of Applied Siences, Bern, BE, Switzerland, [3]Sohard AG, Bern, Switzerland

Introduction:

MR analysis of small bowel motility is a new technique to identify and localize functional pathologies of the small bowel [1, 2]. Besides visual analysis, dynamics quantification has been suggested to describe various peristalsis paradigms [3]. Until now these analyses have been performed by measuring intraluminal diameters of single bowel loops by hand and the measurements were plotted over time. This measurement technique is extremely time-consuming as all measurement points must be corrected due to the inherent motility-movement or shifting of the small bowel segment. The aim of this study was to validate a newly developed software prototype permitting semi-automatic measurement of small bowel diameter over long time periods thus displaying motility.

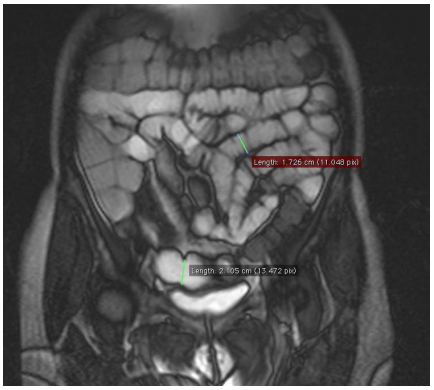

Fig 1: Coronal 2D True-FISP image of a motility sequence of the small bowel. In green color the cross-section diameters are placed manually in orthogonal direction over the selected segment. Each measurement is used for the motility curves illustrated in Fig. 4.

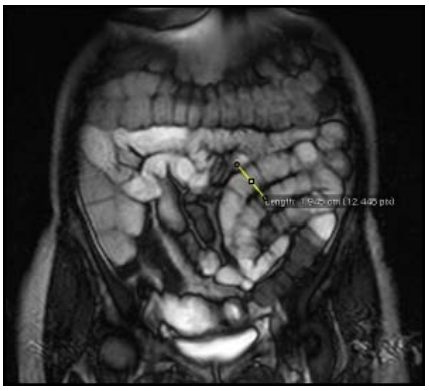

Fig 2: Same 2D True FISP image as in Fig. 1 but with the respective orthogonal cross-section as measured with the semi-automatic software prototype. In this case the line extends over the external boundaries of the wall. Refer to Fig. 3 for further details.

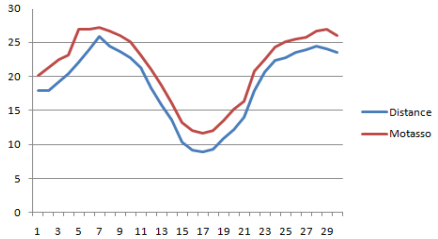

Fig 4: Peristaltic motion covering 15 sec of a single small bowel loop assessed manually (blue) and semi-automatically (red) using Motasso software. Both curves match each other regarding peristaltic frequencies. The slight displacement of both curves is due to the differing definition of the boundaries.

Material and Methods:

52 consecutive clinical patients were included in this institutional review board approved retrospective analysis of small bowel motility. All patients had been referred for the evaluation of small bowel pathologies for various clinical reasons, mainly Crohn's disease. The standardized preparation consisted of an oral uptake of 1000ml of an aqueous 3% Mannitol solution after at least 4 hours of fasting. Patient compliance concerning distension could not be assessed. MRI was performed in prone position on a 1.5-Tesla MR system (Siemens Sonata, Siemens Medical Systems, Erlangen, Germany) using a 4 channel phased-array body coil. 2D motility acquisitions covering the entire small bowel over several layers are part of the standard small bowel protocol used in clinical routine. Coronal 2D trueFISP cine sequences (TR/TE 2.84/1.9; matrix 256 × 256, slice thickness 10mm, slice repetition time 500msec) are acquired in apnea lasting 15 sec resulting in a total of 30 measurement points per acquisition. Image analysis of the same bowel segment was performed both manually and using the semi-automatic software analysis prototype (Motasso). Manual small bowel peristalsis measurements were performed orthogonally to the long axis resulting in cross-sectional diameters of the small bowel over time (Fig. 1). For manual evaluation, cross-section diameters are defined as the intraluminal liquid content with high signal intensity, (Fig 2). For the evaluation by the software prototype the user is asked to place a line over the segment to be measured. The software than analyses the signal intensity distribution over time and measures the distance between the midpoints of the small bowel walls (Fig 3). The main curve characteristics describing motility were compared using the paired Student's t-Test.

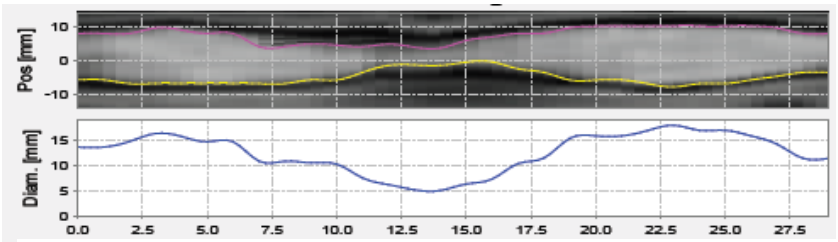

Fig. 3: The upper half indicates the signal intensity distributions over the placed line in Fig 2 plotted over time of 30 time points with a temporal resolution of 0.5sec. The blue curve is the calculated diameter as a difference between the red and the yellow line, which represent the midpoint of the bowel wall on the selected segment. This bowel wall with its low signal intensity is automatically detected by the software prototype.

Results:

In all 52 patients single segments could be measured first manually and then using the software (Fig.4). Overall 110 evaluations were included into the validation. Exemplarily, Fig. 4 demonstrates the high accordance of the manual and semi-automatic measurements. Overall 97/110 (88.2%) of the motility curves were in agreement with each other with 86/110 (78.2%) presenting a parallel shifting of both curves (Fig. 4). This dislocation can be attributed to the differing definition of the external edges of the lumen as described above. No significant difference (p=0.65) was found for the peristaltic frequencies with mean values of 4.06/min (manually) and 4.09/min (semi-automatic), while the amplitudes differed significantly (p=0.011) with 4.58mm (± 3.22) manually and 5.03mm (± 3.45) using the software. Apparently the difference of outer edge definition depending small bowel wall diameters vary in extended and compressed status.

Discussion and Conclusion:

Validation of our newly developed software prototype for quantification of small bowel peristalsis proves as a valuable tool for fast, standardized and accurate measurement of small bowel motility. Feasibility could be proven for a large number of well-depicted small bowel loops of patients suffering small bowel pathologies. While curves and peristaltic motility frequencies both of hand and semi-automatic analysis matched in the large majority of examinations, the significant differences of amplitudes must be attributed to the differing edge definitions of both methods.

References:

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3. Keller J, Layer P: Intestinal and anorectal motility and functional disorders. Best Pract Res Clin Gastroenterol. 2009;23(3):407.