

1 **TITLE**

2 **METHODS OF ANORECTAL MANOMETRY VARY WIDELY IN CLINICAL**  
3 **PRACTICE: RESULTS FROM AN INTERNATIONAL SURVEY**

4

5 **RUNNING TITLE**6 **ANORECTAL MANOMETRY PRACTICE SURVEY**

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37

38 **ABSTRACT**

39 **Background**

40 Anorectal manometry (ARM) is the most commonly performed investigation for  
41 assessment of anorectal dysfunction. Its use is supported by expert consensus  
42 documents and international guidelines. Variation in technology, data acquisition and  
43 analysis affect results and clinical interpretation. This study examined variation in ARM  
44 between institutions to establish the status of in current practice.

45

46 **Methods**

47 A 50-item web-based questionnaire assessing analysis and interpretation of ARM was  
48 distributed by the International Anorectal Physiology Working Group (IAPWG) via  
49 societies representing practitioners that perform ARM. Study methodology and  
50 performance characteristics between institutions were compared.

51

52 **Key results**

53 One-hundred and seven complete responses were included from 30 countries.  
54 Seventy-nine (74%) institutions performed at least 2 studies per week. Forty-nine  
55 centres (47%) applied conventional ARM ( $\leq 8$  pressure sensors) and 57 (53%) high-  
56 resolution ARM (HR-ARM). Specialist centres were most likely to use HR-ARM  
57 compared to regional hospitals and office based practice (63% vs. 37%). Most  
58 conventional ARM systems used water-perfused technology (34/49); solid-state  
59 hardware was more frequently used in centres performing HR-ARM (44/57). All  
60 centres evaluated rest and squeeze. There was marked variation in the methods used  
61 to report results of maneuvers. No two centres had identical protocols for patient

62 preparation, setup, study and data interpretation and no centre fully complied with  
63 published guidelines.

64 **Conclusions and Inferences**

65 There is significant discrepancy in methods for data acquisition, analysis and  
66 interpretation of ARM. This is likely to impact clinical interpretation, transfer of data  
67 between institutions and research collaboration. There is a need for expert  
68 international co-operation to standardize ARM.

69

70

71 **KEYWORDS**

72 Anal manometry

73 Anorectal manometry

74 High-resolution anorectal manometry

75 Anorectal physiology

76 Anorectal dysfunction

77 Faecal / fecal incontinence

78 Constipation

79

80 **KEYPOINTS**

81

82 • There is marked variation in technology employed, data acquisition, analysis  
83 and reporting of ARM results between institutions.

84 • More than half of the centres surveyed use high-resolution ARM for the  
85 performance of anorectal manometry. High-resolution technology was utilized  
86 most often in specialist centres with high throughput.

87 • None of the centres surveyed complied fully with the widely cited guidelines for  
88 'minimum standards' of anorectal manometry.

89

90

91 **ABBREVIATIONS**

92	AGIP	Association of GI Physiologists
93	ANGMA	Australasian Neurogastroenterology and Motility Association
94	ANMA	Asian Neurogastroenterology and Motility Association
95	ANMS	American Neurogastroenterology and Motility Society
96	ARM	Anorectal manometry
97	ENMS	European Neurogastroenterology and Motility Society
98	HR-ARM	High-resolution anorectal manometry
99	IAPWG	International Anorectal Physiology Working Group
100	RAIR	Rectoanal inhibitory reflex
101	USA	United States of America
102	UK	United Kingdom

103

104

105

106 **INTRODUCTION**

107 Several investigations are available for the assessment of anorectal structure and  
108 function in patients who present with intractable symptoms of anorectal dysfunction,  
109 characterised by faecal incontinence and / or disordered evacuation (1-3). Anorectal  
110 manometry (ARM) is the best-established technique available to detect abnormalities  
111 of sphincter function and / or recto-anal co-ordination, which may important causes of  
112 such symptoms (2, 4, 5).

113

114 ARM consists of a series of pressure measurements that assess: (i) involuntary  
115 function of the anal canal during rest, (ii) voluntary function during squeeze, (iii) reflex  
116 recto-anal co-ordination during rectal stimulation, and (iv) voluntary rectoanal co-  
117 ordination during simulated defecation ('push') (3, 4). ARM may also incorporate an  
118 assessment of rectal sensation (4).

119

120 Review articles that describe the ARM technique (3, 4, 6-9) reveal that variations of  
121 study protocol impact the results of this investigation (4, 10-13). This limits clinical  
122 interpretation, transfer of data between institutions and research collaboration. For  
123 these reasons, several position statements and working party reports have provided  
124 guidance on technique for data acquisition, analysis and reporting (1, 4, 8, 14).  
125 Nevertheless, several manometry systems are commercially available and, although  
126 evidence is lacking, it is widely presumed that there is important variation in practices  
127 between institutions (15-21).

128

129 The advent of high-resolution ARM (HR-ARM) has brought with it a new dimension of  
130 data capture and visualization (colour-contour topographical plots), and has the

131 potential to revolutionize appreciation of anorectal function (22-24). Unfortunately, this  
132 advancement has added a further element of variability in practice; unless efforts are  
133 made early to reach consensus on test performance, this technique may fall victim to  
134 the same pitfalls that have bedeviled other investigations in the field.

135

136 To address these knowledge gaps, and to bring consensus, an expert group (the  
137 International Anorectal Physiology Working Group [IAPWG]) was convened to develop  
138 and promote internationally accepted standards for the clinical measurement of  
139 anorectal physiology, with a particular focus on HR-ARM. As a first step, and to better  
140 understand the status of current practice, the group conducted this study to examine  
141 ARM practice in different settings and countries. This work tests the hypothesis that  
142 there is important variation in ARM practice. The objectives are to inform and facilitate  
143 the development of internationally agreed standard operating procedures for data  
144 acquisition and analysis.

145

146



147 **METHODS**

148 **Questionnaire structure**

149 A questionnaire examining features of ARM practice was developed using a web-  
150 based survey and data collection tool ([www.qualitrics.com](http://www.qualitrics.com), Utah, USA). The  
151 questionnaire is available in Supplementary material 1. Existing guidelines (2, 4, 8)  
152 were used to structure the questionnaire to explore the following areas of interest:

- 153 1) department setup / centre activity;
- 154 2) study indications;
- 155 3) manometry technique and equipment;
- 156 4) study protocol;
- 157 5) data analysis and reporting;
- 158 6) additional investigations.

159 'Department setup / centre activity' explored centre location / specialism and volume  
160 of activity performed. 'Study indications' allowed respondents to choose common  
161 reasons for test performance (e.g. faecal incontinence, constipation etc.). 'Manometry  
162 technique and equipment' examined the use of conventional ARM and / or HR-ARM,  
163 and detailed the equipment used. 'Study protocol' comprised a series of questions  
164 related to common manoeuvres performed to assess rest, squeeze, prolonged  
165 squeeze, cough, push (simulated defecation) and the recto-anal inhibitory reflex  
166 (RAIR). 'Data analysis and reporting' explored reporting of test results. 'Additional  
167 investigations' allowed the respondent to list tests used to complement ARM in the  
168 assessment of symptoms of disordered defecation.

169

170 Data were collected in the form of single or compound answer multiple-choice  
171 questions for nominal data, slider bar questions for continuous numerical data and

172 open-ended text boxes for descriptive exploration of complex practices. In particular,  
173 questions exploring measurement parameters were constructed using a `select all that  
174 apply` approach.

175

176 Prior to launch, the questionnaire was piloted by 10 UK institutions to test usability,  
177 understanding, clarity and question flow.

178

### 179 **Questionnaire distribution**

180 Practitioners (clinicians, nurse specialists, and physiologists) who regularly practice  
181 ARM were identified and contacted by email via advocates from the following national  
182 and international societies with an involvement in colorectal function testing: the  
183 Association of GI Physiologists (AGIP) of the British Society of Gastroenterology, the  
184 American Neurogastroenterology and Motility Society (ANMS), the Australasian  
185 Neurogastroenterology and Motility Association (ANGMA), the Asian  
186 Neurogastroenterology and Motility Association (ANMA), and the European  
187 Neurogastroenterology and Motility Society (ENMS). In addition, invitations were sent  
188 to those attending the 2013 Pelvic Floor Society Annual Meeting, and through  
189 clinicians involved in the International Anorectal Physiology Working Group (IAPWG)  
190 to their own clinical contacts with an interest in the field of ARM.

191

192 No incentive was utilised to increase response rate. The survey was distributed  
193 between September 2013 and July 2015. Responses not completed within 7 days of  
194 commencement were discarded.

195

196 This work was undertaken with the endorsement of all societies involved. Data were  
197 collected and held within the requirements of the Data Protection Act. The study did  
198 not use clinical data and did not require or seek specific ethical approval.

199

#### 200 **Statistical analysis**

201 Data were analyzed quantitatively using number of observations and proportions. For  
202 centre activity comparisons, 'high' volume centres were defined as those performing  
203  $\geq 10$  studies per week and 'low' volume centres were defined as those performing  $\leq 2$   
204 studies per week.

205

206 Analyses were performed using a commercially available software package (SPSS  
207 Statistics Version 20: IBM, New York, USA). A P value of  $< 0.05$  was considered  
208 statistically significant.

209

210

211 **RESULTS**

212 **Questionnaire responses**

213 One hundred and nine responses were completed from 125 surveys started (87.2%  
214 completion rate). Two duplicate responses from individuals within the same centre  
215 were received. In each case, the second response was discarded. This left 107  
216 complete surveys available for analysis. Responses were received from 30 countries  
217 as detailed in Table 1.

218

219 **Centre activity**

220 Seventy-nine centres (74%) reported performing more than 2 studies per week with  
221 most reporting activity of between 2 – 10 studies per week (52%). Particularly high  
222 volume activity ( $\geq 20$  studies per week) was reported by 8 (8%) centres and low volume  
223 activity by 13 centres (12%).

224

225 Forty-nine respondents (46%) described their centre as being within a specialist  
226 hospital, 34 (32%) within a general hospital and 24 (22%) within a private hospital or  
227 other institution.

228

229 **Study indications**

230 Ninety-one respondents (85%) reported that ARM was 'always' performed for  
231 assessment of fecal incontinence, with the remaining 16 (15%) reporting that ARM  
232 was 'sometimes' performed for this indication. Eighty-six respondents (80%) reported  
233 'always' performing ARM for assessment of constipation, with the remaining 21 (20%)  
234 reporting 'sometimes'. ARM was less often performed for anal pain (10% never, 65%

235 sometimes, 25% always) and for abdominal pain / bloating (59% never, 34%  
236 sometimes, 7% always).

237

### 238 **Manometry technique and equipment**

239 Fifty-seven (53%) centres reported using HR-ARM. Forty-nine utilised conventional  
240 ARM (47%). One centre reported using both HR-ARM and conventional ARM.

241

242 Of the 49 centres performing conventional ARM, 34 (69%) reported using water-  
243 perfused technology. The remaining 15 (31%) use a solid-state catheter. Water-  
244 perfused systems were far less common in those centres performing HR-ARM, with  
245 only 13 (23%) using this technology and the remaining 44 (77%) institutions using a  
246 solid state catheter.

247

248 There was marked variation in catheter diameter, sensor number and sensor / port  
249 configuration between centres. Catheter diameter varied between 8 – 22F for both  
250 water-perfused and solid-state systems. These data are summarized in Tables 2a and  
251 2b.

252

### 253 **Study protocol and measurement reporting**

#### 254 ***Manoeuvres performed***

255 The only tests consistently performed by all centres during ARM were the rest and  
256 squeeze manoeuvres. For the other manoeuvres, 87 (81%) reported performing  
257 prolonged squeeze, 89 (83%) cough, 89 (83%) push (simulated defecation) and 103  
258 (96%) RAIR.

259

260 **Rest**

261 The time period most frequently used to record anal resting pressure was 1 minute  
262 (76%). The method of reporting most frequently used was 'mean pressure over the  
263 whole anal canal length' (55%). These data are further described in Figure 1.

264

265 As questions were designed as 'select all that apply', it was possible to assess the  
266 combination of measurement parameters utilised by each institution. This analysis  
267 demonstrated that there were 16 combinations of ways in which rest data were  
268 quantitatively reported. The three most common reporting methods were 'mean  
269 pressure over the whole anal canal length' alone (29%), 'mean pressure at different  
270 levels of the anal canal' alone (15%), and 'mean pressure over the whole anal canal  
271 length' together with 'maximum pressure over the whole anal canal' (14%).

272

273 **Squeeze**

274 During assessment of squeeze, 69 (65%) centres routinely asked subjects to squeeze  
275 for a predefined length of time, with 37 (35%) centres allowing subjects to squeeze for  
276 'as long as they were able'. One centre (1%) failed to give valid information on squeeze  
277 characteristics.

278

279 Of those asking subjects to squeeze for a predefined length of time, the most  
280 commonly reported squeeze *duration* was 5 seconds (18% of respondents) however  
281 there was very little consistency between centres, and 26 (24%) centres reported that  
282 requested *short* squeeze duration was >15 seconds. These data are presented in  
283 Figure 2a. There was also marked discrepancy between centres in the *number* of

284 squeeze performed, which varied between 1 and 10. These data are presented in  
285 Figure 3a.

286

287 As with parameters of resting anal pressure, there was marked variation in the  
288 methods used to report results. The two most common squeeze parameters reported  
289 were 'maximum incremental squeeze pressure' (56%) and 'maximum absolute  
290 squeeze pressure' (51%). These data are further explored in Figure 1.

291

292 There were 18 combinations of ways in which squeeze data were quantitatively  
293 reported. The three most common reporting methods were 'maximum incremental  
294 squeeze pressure' alone (21%), 'maximum absolute squeeze pressure' alone (13%),  
295 and 'maximum incremental squeeze pressure' together with 'maximum absolute  
296 squeeze pressure' (12%).

297

### 298 ***Prolonged squeeze***

299 Similar to the results found with squeeze, there was marked variation in the  
300 performance and reporting of *prolonged* squeeze. The *duration* of prolonged squeeze  
301 most frequently reported was 20s or 30s (25% for both) however the reported duration  
302 ranged up to 60 seconds. These data are shown in Figure 2b. There was similar  
303 discrepancy in the *number* of squeezes performed, which varied between 0 and 10.  
304 These data are shown in Figure 3b.

305

306 There was particular variation in results reporting of this manoeuvre. The most  
307 common parameters reported for prolonged squeeze were 'duration of squeeze above  
308 50% maximum pressure' (47%). These data are shown in Figure 1.

309

310 There were 43 combinations of ways in which prolonged squeeze data were  
311 quantitatively reported. The two most common reporting methods were 'duration of  
312 squeeze above 50% maximum pressure' alone (20%) and 'maximum absolute  
313 pressure' alone (10%).

314

### 315 ***Cough***

316 As previously, there was marked variation in the performance and reporting of the  
317 cough manoeuvre. The *number* of cough manoeuvres performed varied between 1  
318 and 10.

319

320 Notably, 36 centres (40%) reported that they do not use quantitative values to describe  
321 results and that instead qualitative assessment of muscle recruitment is utilised. Of  
322 those using quantitative measures, the most common metric used was 'maximum anal  
323 pressure during cough', which was reported by 28 (31%) of these institutions. These  
324 data are shown in Figure 1.

325

326 There were 12 combinations of ways in which cough data were quantitatively reported.  
327 The two most common combinations were the use of 'maximum anal pressure' alone  
328 (12%) and 'maximum rectal pressure during cough' together with 'maximum anal  
329 pressure during cough' (10%).

330

### 331 ***Push (simulated defecation)***

332 As with other manoeuvres, there were notable dissimilarities in test performance and  
333 results reporting of push between centres. Of the 89 institutions that reported



334 performing push, the majority (91%) performed this test with the subject in the left  
335 lateral position. Interestingly, 6 centres (7%) performed the study in both in the left  
336 lateral *and* the sitting position, 1 centre (1%) performed studies in the left lateral *and*  
337 supine position and 1 centre (1%) performed studies in the left lateral, supine *and* the  
338 sitting position (Table 3). As seen previously for other manoeuvres, there was  
339 particular variability in the *number* of push manoeuvres performed, which varied  
340 between 1 and 10. These data are shown in Figure 3 c.

341

342 For the performance of this test, 65 (73%) centres reported the use of a rectal balloon  
343 associated with the manometry catheter. Nine centres (14% of those using a balloon)  
344 routinely fill the balloon to the subjects' first sensory volume, 9 (14%) to the subjects'  
345 defaecatory desire volume and 45 (69%) to a pre-defined fixed amount. Two (3%)  
346 institutions did not provide information about balloon filling. For those reporting the use  
347 of a predefined amount for balloon inflation, the most commonly used amount of air  
348 was 50 ml, which was reported by 27 (64%) of these institutions.

349

350 For reporting of the push manoeuvre, in the context of a 'select all that apply' question  
351 format, 21 (24%) centres report push qualitatively from colour contour / line traces and  
352 47 (53%) provide quantitative reports using either in-built analysis software or by  
353 deriving values manually from line traces. Twelve (13%) stated that they only report  
354 practitioner evaluated visualisation of appropriate muscle recruitment / co-ordination.  
355 Twenty-nine centres (33%) did not give information on how push was manometrically  
356 reported.

357

358

359 **RAIR**

360 Overall 103 centres routinely perform RAIR assessment. Of these, the majority  
361 perform one RAIR during each study (39%). Again however, there was great  
362 variability, with 2 centres (2%) reporting that they routinely perform 10 RAIRs as part  
363 of their standard clinical protocol. These data are shown in Figure 3d.

364

365 Thirty-six centres (36%) report provoking RAIR by incremental inflation of a rectal  
366 balloon by fixed volumes of air, and 17 (17%) with only a *single* fixed volume of air.  
367 Forty-eight (47%) did not provide information about the inflation method for the  
368 provocation of RAIR.

369

370 Thirty (29%) centres reported measuring the RAIR quantitatively, 37 (36%)  
371 qualitatively (as present / absent), and 34 (33%) both quantitatively and qualitatively.  
372 Six (6%) centres did not provide information of the method used for RAIR reporting.

373

374 **Additional investigations**

375 No centre reported performing ARM in isolation. All centres reported that they perform  
376 at least one other complimentary test of anorectal structure / function (Table 4).

377

378 **Comparison between centres using conventional ARM or HR-ARM**

379 Some differences were seen in demographics and practices when comparing those  
380 centres performing conventional ARM versus those performing newer HR-ARM.  
381 Within this survey sample, HR-ARM is more frequently utilised by specialist and  
382 private hospitals (43/67 [64%] vs. 36% performing conventional ARM), whereas  
383 conventional ARM is more frequently performed in general hospitals (23/34 [68%] vs.

384 11/34 [32%] performing HR-ARM). Activity between conventional ARM and HR-ARM  
385 performing centres was similar, with 6 (6/49 [12%]) conventional ARM vs. 7 (7/57  
386 [12%]) HR-ARM centres reporting low volume activity and 6 (6/49 [12%]) conventional  
387 ARM vs. 9 (9/57 [16%]) HR-ARM centres reporting high volume activity.

388

389 HR-ARM was more commonly reported amongst centres from North and South  
390 America (used by 27/36 [75%]). By contrast, it appears that conventional ARM  
391 remains popular in the rest of the world with 8 (8/14 [57%]) centres from Asia, the  
392 Middle East and Australia and 35 (35/57 [61%]) of European centres continuing to use  
393 this technique.

394

395 Despite difficulties in interpreting the widespread variation in methods used to report  
396 manometric findings, there was an apparent higher frequency of more integrative or  
397 qualitative measures of anorectal function used by centres with HR-ARM. Pertinent  
398 examples include:

- 399 • rest - 'mean pressure over the anal canal' reported by 17 (17/49 [35%])  
400 conventional ARM centres vs. 42 (42/57 [74%]) HR-ARM centres;
- 401 • push - 'qualitative reporting of anorectal co-ordination' was utilized by 3 (3/49  
402 [6%]) conventional ARM centres vs. 18 (18/57 [32%]) HR-ARM centres;
- 403 • cough - 'qualitative visualisation of muscle recruitment / co-ordination' was  
404 reported by 6 (6/49 [12%]) conventional ARM centres vs. 20 (20/57 [35%]) HR-  
405 ARM centres.

406

407 **Compliance with guidelines**

408 Results were compared with the protocol outlined in the most widely accepted  
409 guideline for ARM (4). This manuscript recommends a minimum 6-sensor catheter  
410 with performance of rest, squeeze, cough, push and RAIR maneuvers and suggests  
411 reporting of the following basic parameters: `maximum anal resting pressure at  
412 intervals within the anal canal ', 'maximum anal squeeze pressure', 'maximum  
413 sustained squeeze pressure', 'squeeze duration', 'rectoanal pressure difference  
414 during cough', 'residual anal pressure during push' and 'combined qualitative /  
415 quantitative reporting of the RAIR'. Only three centers complied with the suggested  
416 performance protocol. None of the 107 centers surveyed complied with both the  
417 recommended protocol and method for results reporting. In addition, no two centers  
418 reported identical protocol and analysis techniques.

419

420

421 **DISCUSSION**

422 This study confirms the long held impression that striking variation exists in the current  
423 practice of ARM. Differences between institutions exist in study indications, equipment  
424 used, manometry technique, data acquisition, analysis and reporting. No centre  
425 responding to this survey fully complies with previously published and widely cited  
426 'minimum standards' for ARM (4). In particular, there is dissimilarity in the parameters  
427 used to report results, a factor that makes accurate comparisons between institutions  
428 and further development of the technique challenging.

429  
430 In an environment in which several commercial entities are developing and  
431 manufacturing diagnostic technologies, a degree of variation is inevitable and may be  
432 welcomed for the purposes of innovation. However, when such techniques are applied  
433 to clinical practice, nuance in equipment characteristics can have important effects on  
434 manometry measurements. This has been studied in both the upper and lower GI  
435 tract, and although most studies report good correlation between techniques, absolute  
436 values do significantly differ (12, 25-28). This represents a challenge to  
437 standardisation, as until robust evidence on actual differences in measurement and  
438 analysis exists, practitioners will continue to be driven by personal/institutional  
439 preference when choosing device and equipment specifications.

440  
441 It is clear that the introduction of HR-ARM has brought with it further variability (9).  
442 This survey demonstrates that although conventional ARM is most commonly used in  
443 combination with water-perfused technology (69% of institutions surveyed), many of  
444 those with more novel HR-ARM systems have chosen to use solid-state hardware  
445 (77% institutions surveyed). The impact of these differences in hardware/software

446 combinations is yet to be quantified in the anorectum, however studies in the  
447 oesophagus indicate that the choice of technology and can impact diagnostic decision-  
448 making (29-32).

449

450 In addition, although (limited) normal values for different catheter types and  
451 populations exist (15, 33-36), a robust description of pathological measurements seen  
452 using HR-ARM is yet to be established. This is likely to explain our finding that,  
453 compared to those using conventional ARM, clinicians using modern HR-ARM  
454 equipment put more emphasis on qualitative descriptions of global anorectal function  
455 than quantitative pressure measurements. Data expression using the colour-contour  
456 display requires a illustrative approach, and in the oesophagus at least, this has been  
457 shown to significantly aid data interpretation and analysis (37).

458

459 Differences in practice were not limited to hardware/software combinations, but  
460 appeared to pervade all aspects regarding performance of the technique. The impact  
461 of variation in study protocol on ARM results and management of patients with  
462 anorectal disorders has not been robustly tested however, it has been shown that  
463 changes in patient position, doctor-patient interaction and data analysis all have  
464 important effects on anorectal measurements that can impact on clinical diagnosis  
465 (13, 38, 39).

466

467 A number of features found during investigation of study protocol invite discussion. Of  
468 particular interest was the finding that the majority of centres perform push in the left  
469 lateral position. Although sitting is clearly more physiological, only 8% of centres chose  
470 to investigate patients in this manner. It is often argued that testing in the left-lateral

471 position is one reason for the high rate of dyssynergia in both healthy and patient  
472 populations (40, 41) and investigation in the upright-seated position has been shown  
473 to influence rectal and anal pressure (42, 43). Certainly further exploration of the  
474 impact of patient position is warranted.

475

476 Another area for consideration is the near universal (96% of institutions surveyed)  
477 assessment of the RAIR. Although this is viewed as a useful screening test in  
478 paediatric populations (to exclude the presence of Hirschsprung disease) no formal  
479 evidence of the application of this test in adult populations exist (44, 45), especially as  
480 new diagnosis of this disorder in adults is exceptionally rare and usually made on  
481 clinical, radiological and histological grounds.

482

483 Additionally, despite a lack of evidence for its diagnostic utility (4, 8, 46), cough was  
484 performed by 83% of centres. The majority reported qualitative values and when  
485 quantitative values were reported there was significant variation in results reporting.  
486 The significant variation in results reporting between centres surveyed seem to  
487 indicate that the rationale for this test is poorly understood.

488

489 The finding of discordance in results reporting is particularly interesting. Although  
490 current guidelines recommend the utilisation of certain measures for resting and  
491 squeeze pressure (4, 8, 46) the diagnostic value of the different measures for  
492 discriminating health and disease states is limited (46, 47). This is likely in part to  
493 explain the finding that there were 16 combinations of ways in which rest, 18  
494 combinations of ways in which squeeze and 43 combinations of ways in which  
495 prolonged squeeze data were quantitatively reported. This inconsistent use of

496 terminology and methods for data acquisition and analysis of ARM findings requires  
497 specific discussion because at the very least, such practice can cause confusion when  
498 communicating results between practitioners both in the clinical setting and also when  
499 published in the literature. This variability can be partly explained by the fact that there  
500 are few published studies that investigate the *comparative* utility of individual  
501 manometric measures. There is no evidence to date that demonstrates that one  
502 manometric measure conveys superior diagnostic information to another. In addition,  
503 although it is well accepted that sphincter pressures are lower in patients with faecal  
504 incontinence than in health (48-57) there is only limited evidence that the *degree* of  
505 functional abnormality of the sphincter is related to symptom severity or predictive of  
506 treatment success (57-61).

507

508 Guidelines for the diagnosis and management of anorectal disorders recommend  
509 more than one test to better characterize pathophysiology and guide treatment. (8, 62,  
510 63). The findings of this study show, that the majority of centres surveyed do utilize  
511 allied tests such as balloon expulsion, rectal sensation testing and measurement of  
512 colonic transit for assessment of anorectal dysfunction. However information in the  
513 literature on agreement of adjunctive tests and their results with HR-ARM especially  
514 in the diagnosis of evacuation disorders is conflicting (64, 65). Up to this time point no  
515 studies have investigated the added diagnostic value of different adjunctive testing  
516 methods to allow the recommendation of standardized testing sequences of HR-ARM  
517 and adjunctive tests for faecal incontinence or evacuation disorders.

518 For this reason published guidelines have been generally based on expert experience  
519 and opinion rather than an objective comparison of the utility of different manometric  
520 measures or adjunctive tests (3). Indeed, this lack of consensus may be the reason



521 for the relatively slow adoption and rate of publication with HR-ARM compared to  
522 oesophageal HRM for which a well-established method and classification system  
523 exists (66).

524

525 The authors acknowledge a number of limitations within this study. The first is the  
526 method for identification of potential respondents. Efforts were made to identify as  
527 many centres as possible through interaction with the societies with an interest in  
528 investigation of anorectal function and contacts of the IAPWG. This convenience  
529 sample may not necessarily be representative of global practices as a whole,  
530 particularly as some centres (especially low volume centres which do not engage  
531 formally with the societies) may have been underrepresented in the sample. In  
532 particular, over 27% of responses were collected from British centres. Therefore,  
533 although responses have been collected from 6/7 continents of the world, it would be  
534 fair to suggest that results may not be a true reflection of global practices with some  
535 bias to practices within the UK and Europe. The second limitation is the likely survey  
536 nonresponse bias. As the survey was distributed by third-parties to mailing lists no  
537 data pertaining to response rate were collected. It is possible that these non-  
538 respondents differed in meaningful ways from those who completed the survey  
539 resulting in voluntary response bias.

540

541 Third are the limitations implicit in design of this pragmatic questionnaire. Due to the  
542 complexity of results recording, options for reporting of certain manometric measures  
543 and measures of centre activity had to be given as close ended, leading questions.  
544 This may have led to response bias due to the lack of study blinding and desire of the  
545 respondent to give a 'correct' response. Questions did not force a response, which led

546 to some missing data, particularly for cough and RAIR characteristics. Additionally,  
547 there was no data accuracy / question check in place. It is possible that inattention  
548 from respondents may have led to inaccurate responses. This may be an explanation  
549 for the finding that endurance squeeze duration in some centres was less than 10  
550 seconds.

551

552 This study provides the first formal evidence of major discordance in international  
553 practices of anal manometry. It has demonstrated that methods of both data collection  
554 and results reporting are extremely variable and it appears that many centres are not  
555 following currently acknowledged best practice. This disparity is likely to be limiting the  
556 utility of this technique, preventing data comparison between institutions and may be  
557 impacting on clinical decision-making.

558

559 This study provides a basis for consensus generation in regards to manometric data  
560 acquisition and analysis of anorectal measurements akin to the Chicago process for  
561 assessment of oesophageal function (67). Such agreement on standard operating is  
562 urgently required to reduce undesirable variations in practice and ultimately, the  
563 formation of good clinical guidelines for anorectal manometry is likely to have a  
564 significant impact on both the clinical and research applications of this technique.

565

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854  
855

856 **TABLES**

857

858 **Table 1.** Frequency of respondents' location by country.

859

<b>Country</b>	<b>Frequency</b>	<b>%</b>
United Kingdom	29	27.1
United States	15	14
Mexico	11	10.3
Germany	8	7.5
Italy	5	4.7
Switzerland	5	4.7
Australia	4	3.7
Argentina	3	2.8
Chile	2	1.9
Ireland	2	1.9
Korea, Republic of	2	1.9
Malaysia	2	1.9
Spain	2	1.9
Colombia	1	0.9
Costa Rica	1	0.9
Ecuador	1	0.9
Egypt	1	0.9
France	1	0.9
Guatemala	1	0.9
India	1	0.9
Netherlands	1	0.9
Nicaragua	1	0.9
Poland	1	0.9
Russia	1	0.9
Singapore	1	0.9
South Africa	1	0.9
Sweden	1	0.9
Thailand	1	0.9
Turkey	1	0.9
United Arab Emirates	1	0.9
<b>Total</b>	<b>107</b>	<b>100</b>

860

**Table 2.** Frequency tables of channel number and distribution for (a) water-perfused and (b) solid-state catheter systems used by respondents.

<b>(a)</b>	<b>Water perfused manometry: Number of water-perfused channels</b>	<b>Frequency</b>	<b>%</b>
	2 - 4	8	17
	5 - 8	30	63.8
	9 - 11	2	4.3
	>12	6	12.8
	I'm not sure	1	2.1
	<b>Total</b>	47	100
	<b>Water perfused manometry: Arrangement of water-perfused channels</b>	<b>Frequency</b>	<b>%</b>
	Longitudinally	5	10.6
	Spirally	25	53.2
	Radially	12	25.5
	Longitudinally and radially	4	8.5
	I'm not sure	1	2.1
	<b>Total</b>	47	100
<b>(b)</b>	<b>Solid state manometry: Number of solid-state sensors</b>	<b>Frequency</b>	<b>%</b>
	1	1	1.7
	2 - 4	11	18.6
	5 - 8	7	11.9
	9 - 12	18	30.5
	13 - 20	2	3.4
	21 - 40	4	6.8
	>40	11	18.6
	I'm not sure	5	8.5
		<b>Total</b>	59
	<b>Solid state manometry: Arrangement of solid-state sensors</b>	<b>Frequency</b>	<b>%</b>
	Longitudinally	1	1.7
	Spirally	15	25.4
	Radially	8	13.6
	Longitudinally and radially	29	49.2
	I'm not sure	6	10.2
	<b>Total</b>	59	100

**Table 3.** Frequency table of patient positioning during the push manoeuver.

<b>Position during push manoeuver</b>	<b>Total N=89</b>	
	<b>n</b>	<b>%</b>
Supine	5	5
Left Lateral	81	76
Sitting on a commode	11	10
Other	1	1

**Table 4.** Frequency tables showing use of additional investigations of anorectal function.

Associated investigations	Never		Sometimes		Always		Total
	n	%	n	%	n	%	n
Anal electromyography	92	85.9	13	12.1	2	1.9	107
Anal endosonography (endoanal ultrasound)	59	55.1	36	33.6	12	11.2	107
Anal sensation (electrical stimulation)	83	77.5	15	14	9	8.4	107
Balloon expulsion	26	24.3	23	21.5	58	54.2	107
Colonic scintigraphy	87	81.3	19	17.8	1	0.9	107
Colonic transit	21	19.7	47	43.9	39	36.4	107
Evacuation proctography	38	66.3	45	42.1	24	22.4	107
Pudendal nerve function (terminal motor latencies)	49	45.8	24	22.4	34	31.8	107
Rectal sensation (balloon distension)	52	48.6	7	6.5	48	44.9	107
Rectal sensation (electrical stimulation)	88	82.2	10	9.3	9	8.4	107
Rectal sensation / compliance (barostat)	88	82.2	9	8.4	10	9.3	107
Saline continence test	69	64.4	19	17.8	19	17.8	107

## **FIGURE LEGENDS**

- Figure 1:** Table and diagram showing frequency of measurement parameters utilised for rest, squeeze, prolonged squeeze and cough during ARM protocols.
- Figure 2:** Comparative histograms of (a) squeeze and (b) prolonged squeeze showing maneuver duration reported during ARM protocols.
- Figure 3:** Comparative histograms of (a) squeeze, (b) prolonged squeeze, (c) push and (d) RAIR showing number of maneuvers performed during ARM protocols.