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Medication reconciliation enhances the accuracy of gastric emptying scintigraphy

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Abstract

Background Gastroparesis (GP) is a prevalent sensorimotor disorder characterized by delayed gastric emptying without mechanical obstruction, posing significant diagnostic challenges. Gastric emptying scintigraphy (GES) is the gold standard for diagnosing GP. However, its accuracy can be compromised by many medications that affect gastric motility. This study evaluates the impact of medication reconciliation on the diagnostic accuracy of GES.

Results A significant proportion of patients (75%) were on medications known to affect gastric motility. Recommendations for medication adjustments were communicated, with 30% non-adherence. Adjustments in GES interpretations were necessary for 20% of patients following comprehensive medication reviews. The involvement of radiopharmacists facilitated accurate diagnostic conclusions, underscoring the critical role of medication reconciliation in GES accuracy.

Conclusion Medication reconciliation enhanced the accuracy of GES in diagnosing gastroparesis, emphasizing the need to integrate clinical pharmacy practices into nuclear medicine. This interdisciplinary approach not only improves diagnostic accuracy but also enhances patient safety, advocating for the adoption of such practices in the management of gastroparesis.

Keywords Gastroparesis, Gastric emptying scintigraphy, Medication reconciliation, Radiopharmacy, Patient safety

Background

Gastroparesis (GP) is a prevalent sensorimotor gastric pathology characterized by symptomatic delayed gastric emptying in the absence of any mechanical obstruction (Ye et al. 2021, 2022; Banks et al. 2022). Gastric emptying scintigraphy (GES) is considered the gold standard for diagnosing gastroparesis (Shin and Camilleri 2013). The standard protocol recommends conducting repeated SPECT imaging at intervals of 30 min, 1 h, 2 h, and 4 h post-consumption of a meal mixed with 37 MBq of [^{99m}Tc]technetium–radiolabeled human albumin nanocolloids, usually scrambled eggs and two slices of toast, adapted from the French Nuclear Medicine Society (SFMN) (Banks et al. 2022; Pascal et al. 2022; Johnson et al. 2020). The gastric retention index (GRI) is calculated at each time

point using the Elashoff curve fitting method, which is widely accepted for diagnosing delays in gastric emptying (Maurer 2012).

Management strategies for gastroparesis aim at identifying the root causes and providing symptomatic relief, commonly through antiemetic and prokinetic medications like metoclopramide, domperidone, and erythromycin (Pascal et al. 2022; Camilleri et al. 2022). Additionally, various other drugs can influence stomach motility, potentially affecting GES outcomes (Hasler 2011; Jalleh et al. 2022). To mitigate bias, GES guidelines recommend suspending such medications, including opioids and benzodiazepines, 48 h before GES (Abell et al. 2008). However, these guidelines may not cover all medications affecting gastric motility (e.g. GLP-1 analogs), and their implications on GES are not always known, thus justifying further investigation.

Prior to GES, providing patients with medication guidance is crucial to avoid potential interactions. Yet, this task is often supported by administrative staff who may lack comprehensive pharmaceutical knowledge. The recent involvement of hospital pharmacists in managing polypharmacy, patient education and medication adherence can minimize drug-drug interactions and contribute to cost savings (Lattard et al. 2023). Nevertheless, integrating these practices into nuclear medicine has been challenging due to the specialty's unique demands (Patel and Bhatt 2014).

Radiopharmacists, bridging conventional pharmacy and radiopharmaceuticals, are ideally positioned to conduct optimized medication reconciliation following the French Clinical Pharmacy Society (SFPC) standards (Recommandations de bonnes pratiques – bonnes pratiques de pharmacie clinique 2022).

This study aimed to evaluate the impact of medication reconciliation on the accuracy of medical diagnoses in patients undergoing GES, underscoring the potential advantages of incorporating radiopharmacy expertise into patient care protocols for gastroparesis.

Methods

Study design

A 3-month prospective study was conducted in collaboration between the radiopharmacy and the nuclear medicine department of the University Hospitals of Marseille (AP-HM). The study included 40 patients (average age: 55.3 ± 15.9 years; male-to-female sex ratio: 0.38). Each patient underwent a standardized 4-hour GES protocol using a solid meal mixed with [^{99m}Tc]technetium–radiolabelled human albumin nanocolloids (37.1 ± 1.3 MBq) (Pascal et al. 2022; Garrigue et al. 2017). This protocol received approval from the institutional review board (IRB number PADS20-269; Fig. 1).

Recommendations and medication review

In the week preceding the GES, radiopharmacists compiled a comprehensive list of each patient's medications, cross-referencing the hospital's internal patient records (Axigate® software, aXigate), the patient's pharmacist and/or regular medical doctor, and conducted patient interviews. Additionally, patient allergies, comorbidities, and the use of non-conventional medicines, such as herbal supplements, were documented. Based on this review, radiopharmacists advised patients on which medications to discontinue or continue before undergoing GES, with regards to the French recommendations (Pascal et al. 2022) and the international consensus guidelines and literature (Abell et al. 2008; Wise et al. 2021; Lacy et al. 2023). A report included patient interviews, comorbidities

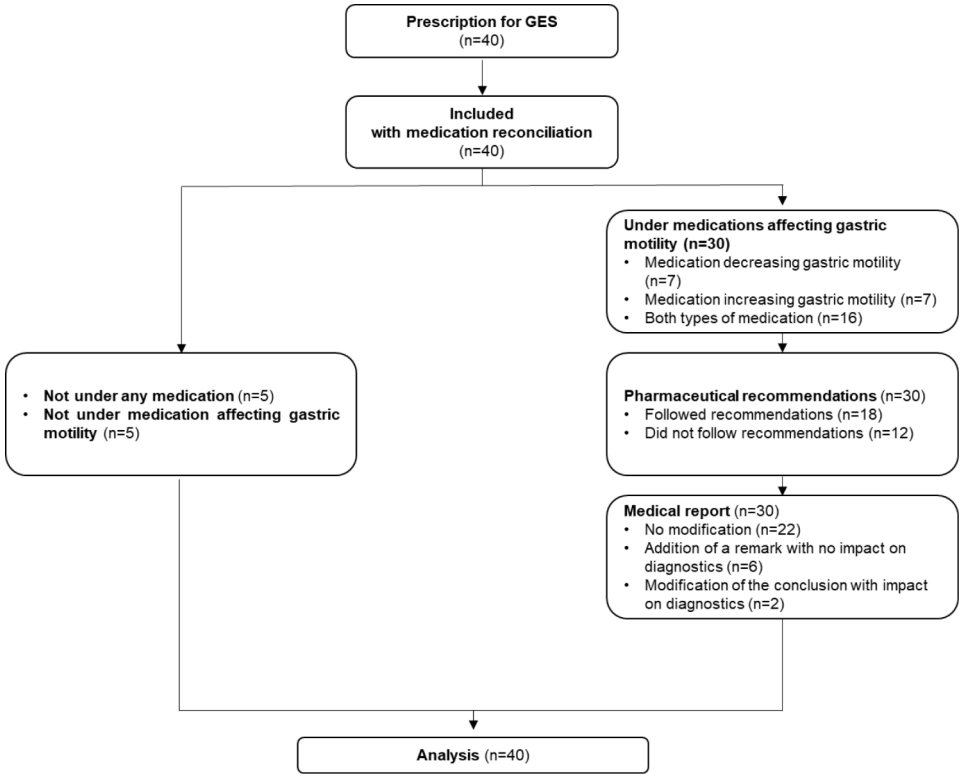

Fig. 1 Flow diagram of the study selection process

and medication reconciliation. Medications were categorized using the Anatomical Therapeutic Chemical (ATC) classification system as defined by the World Health Organization.

Gastric emptying scintigraphy and interpretation

On the day of the GES procedure, radiopharmacists verified patient adherence to medication guidelines. Any further recommendations were anonymously communicated to the performing nuclear medicine physician. Imaging was conducted using a Symbia Evo SPECT/CT system (Siemens Healthcare) with a LEHR collimator in a 180° detector configuration. Six anterior and posterior planar images were captured at intervals of 0, 30, 60, 120, 180, and 240 min post-administration of the [^{99m}Tc]Tc-labelled meal, with each image acquisition lasting 3 min.

Initial GES analyses were performed by physicians and results were drafted blinded to the medication reports. Following these preliminary interpretations, the medication report was reviewed by the physician, potentially leading to adjustments in the interpretative conclusions. Adjustments were classified as: no change, addition of statements, or modification of initial conclusion. Results were analyzed using Prism v.10 software (GraphPad) and expressed as mean ± SD.

Results

During the study period, 87.5% of the participants were on medication. Of these, 82% were undergoing initial diagnosis with GES. Comorbidities were present in 72.5% of the patients, averaging 1.2 ± 0.8 comorbidities per patient. The most common comorbidities

included gastroesophageal reflux (4%), asthma (6%), hypothyroidism (6%), daily alcohol consumption (6%), type 1 or 2 diabetes (8% and 12%, respectively), smoking (12%), and high blood pressure (18%). Other comorbidities accounted for 29% of the total observed pathologies.

Patients were typically prescribed multiple medications, with an average of 5.3±4.4 drugs per patient. Notably, 75% of these patients were taking at least one medication known to affect gastric motility, averaging 1.8±1.6 such drugs per patient. Overall, 34% of all medications taken impacted stomach motility, with 18% being prokinetic agents and 16% known to slow gastric emptying. Details are summarized in Fig. 2.

Interestingly, 40% of patients were found to be taking medications that both accelerate and decelerate stomach motility simultaneously, resulting in quite an unpredictable overall effect on gastric motility.

Recommendations to discontinue at least one treatment were communicated to 30 patients (75%). The day-of-procedure interview revealed that 12 patients (40%) did not adhere to these recommendations. Non-compliance necessitated modifications in the records of 5 patients (42% of non-compliant patients), including the addition of 3 new mentions and the re-evaluation of conclusions for 2 patients.

Furthermore, comprehensive medication reviews led to modifications in the medical reports of 3 patients (7.5% of the total study population) by nuclear physicians (Fig. 2). Finally, 20% of the total cohort were impacted with modifications of the GES medical report conclusions (Table 1).

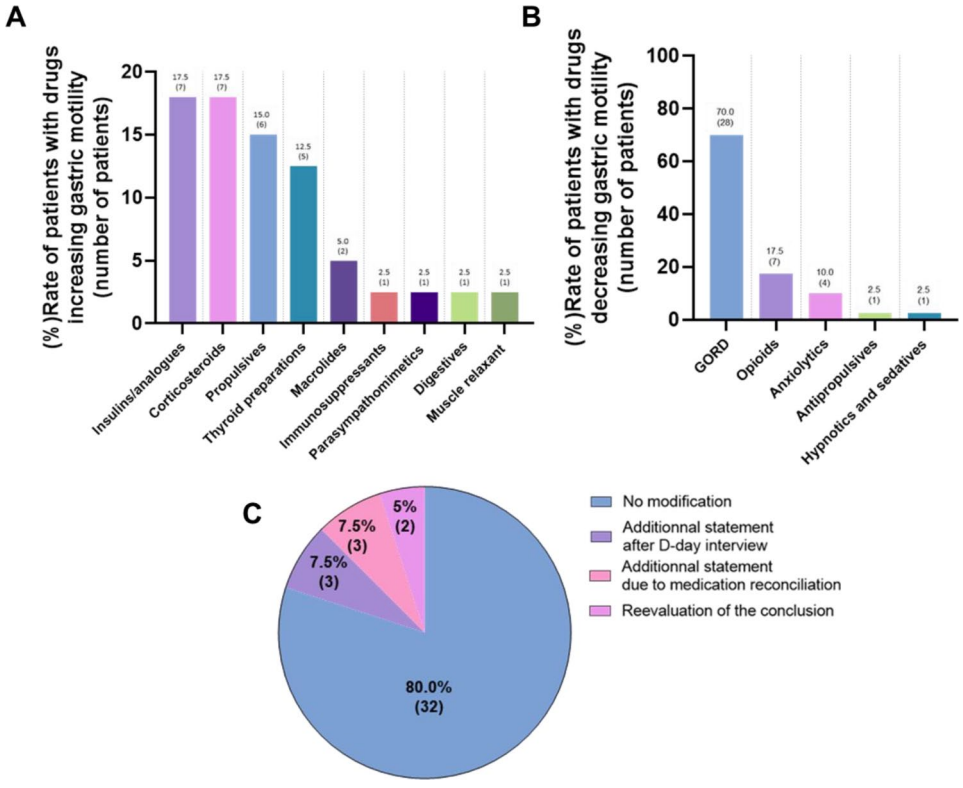

Fig. 2 Analysis of Prescribed Medications in GES Patients. Rate of patients with a medication increasing gastric motility (**A**). Rate of patients with a medication decreasing gastric motility (**B**). Modification rates of gastric emptying scintigraphy reports (**C**). GORD: drugs for peptic ulcer and gastroesophageal reflux disease

Table 1 Detailed review of comorbidities and medications in patients impacted by medication reconciliation COPD: chronic obstructive pulmonary disease

Age	Sex	Comorbidities	First diagnosis	Medications affecting gastric motility (Total medications)	Pharmacological classes prescribed	Compliance with recommendations	Potential impact on gastric motility	Impact of medication reconciliation on GES conclusions
75	F	Glaucoma Myocardial infarction Dislipidemia	Yes	3 (17)	- Proton pump inhibitor - Benzodiazepine - Benzodiazepine-like	Yes	↘↘↘	Addition of statements
48	F	Type 2 diabetes Hypertension Hypothyroidism	No	4 (16)	- Proton pump inhibitor - Opioids - Thyroid hormone	**No**	↘↘↘	**Modification of initial conclusion**
76	H	Coronary disease Dislipidemia COPD Depressive syndrome	Yes	4 (10)	- Proton pump inhibitor - Local anticholinergic - Tetracyclic antidepressants - Atypical antipsychotic	Yes	↘↘↘	Addition of statements
60	F	Type 1 diabetes (grafted) Hypothyroidism	Yes	3 (7)	- Proton pump inhibitor - Thyroid hormone - Corticoids	**No**	↘	Addition of statements
48	F	Functionnal colopathy Depressive syndrome	Yes	5 (7)	- Proton pump inhibitor - Benzodiazepine - Selective Serotonin Reuptake Inhibitor	**No**	↘↘	Addition of statements
53	F	Crohn-like inflammatory disease Hiatal hernia Ankylosing spondylitis	Yes	3 (3)	- Proton pump inhibitor - Benzodiazepine - Anti-D2 - Selective Serotonin Reuptake Inhibitor	**No**	↘↘↘	**Modification of initial conclusion**
49	F	Intermitent porphyria Systemic sclerosis	No	3 (9)	- Proton pump inhibitor - Anti-D2 - Corticoids	**No**	↘	Addition of statements
46	F	Lupus Asthma Myasthenia	No	5 (9)	- Proton pump inhibitor - Antiacid - Anti-D2 - GABA receptor agonist - Cholinesterase inhibitors	Yes	↘↘	Addition of statements

Discussion

Clinical pharmacy has demonstrated benefits for patient care in many specialties but has yet to be fully integrated into the field of nuclear medicine. Echoing our previous research on the positive impact of pharmaceutical interviews in myocardial perfusion scintigraphy, we suggest that radiopharmacists could similarly enhance care in GES by reconciling medications that influence gastric motility (Nail et al. 2021; Implementation of ward-based clinical pharmacy services in Belgium–description of the impact on a geriatric unit. - PubMed - NCBI). Prescribing errors, a major clinical and economic burden, can precipitate adverse drug events, extend hospital stays, and incur substantial costs (D'hulster et al. 2022). Although clinical pharmacy has evolved to reduce such events in general medicine, its adoption in nuclear medicine remains limited due to the minimal adverse effects associated with radiopharmaceuticals (Meher et al. 2021). Regarding nuclear medicine, clinical pharmacy can be set when medications potentially interact with the biodistribution of the radiopharmaceutical drug and eventually lead to inaccuracies in medical interpretation. In this case, GES is a perfect candidate because gastric motility is influenced by various pharmacological mechanisms involving neurotransmitters, hormones, and receptor interactions. Recommendations prior to GES therefore focus on few prokinetic agents. Dopaminergic agents (i.e. metoclopramide and domperidone) and motilin agonists (i.e. erythromycin) enhance gastric motility respectively by antagonizing D2 receptors, increasing acetylcholine release and stimulating smooth muscle contractions via the motilin receptors. Other pathways could be involved such as 5-HT3 serotonin receptor. Antipropulsive effects are mainly described in opioids (i.e. morphine) which inhibit gastric motility by activating μ opioid receptors, leading to decreased acetylcholine and delayed gastric emptying. Anticholinergics and calcium channel blockers can also reduce motility by inhibiting smooth muscle contractions respecting (decreasing the action of acetylcholine or the intracellular concentration of calcium), while histamine, acting through H2 receptors (i.e. ranitidine) and aluminium-containing antiacids (i.e. aluminium hydroxide) mainly influence gastric acid secretion but also indirectly affects motility. To be noted, many other molecules can influence gastric emptying such as GLP-1 analogues; hormones (i.e. thyroid hormone) or alpha-adrenergic agents for instance. In complement to their individual effects, the combination of these agents with each other or with other medications, along with the complexities of pharmacokinetic and pharmacodynamic interactions, further complicates the interpretation of their impact on gastric motility (Anandabaskar 2021). Additionally, specific physiological status could play a key role with fluctuations in hormones. Menstrual cycle can significantly affect gastric motility, such as progesterone playing a key role. During the luteal phase, elevated levels of progesterone have been shown to slow gastric emptying, potentially exacerbating symptoms of gastroparesis or other gastric motility disorders. This hormonal influence can complicate the interpretation of GES results, particularly in premenopausal women, and highlights the need for careful consideration of the menstrual cycle phase when scheduling and interpreting GES (Dilmaghani et al. 2023; Tutar et al. 2023).

In this context, the radiopharmacist is the most appropriate healthcare professional to detect potential interactions between conventional medications, radiopharmaceuticals, and GES (Ye et al. 2021, 2022).

To address these challenges, radiopharmacists collaborated with nuclear physicians to refine the list of medications influencing gastric motility for more accurate GES interpretations based on French GES recommendations. Comprehensive medication reviews enhance the adherence of standards (Abell et al. 2008; Anandabaskar 2021; Wise et al. 2021; Weber 2024). Our findings indicate that a considerable portion of our patient cohort was polymedicated, with 87.5% taking drugs that affect gastric motility. The radiopharmacist's expertise is an invaluable addition to patient care by informing, advising, and identifying the impacts of these medications.

Adherence to medical advice remains an issue, with up to 30% of patients non-compliant (DiMatteo 2004; Miller 2016). In the context of GES, this nonadherence can still lead to non-interpretable or delayed exams. Compared to the literature, radiopharmacist interviews did not reduce non-adherence rates. However, identifying these patients by extensive interviews on the day of the exam allowed for modifications in 42% of their reports ($n=5$), including 3 precisions and 2 modifications of the conclusion. Furthermore, recognizing new medications affecting gastric emptying resulted in a 7.5% increase in additional or modified statements.

To our knowledge, the role of radiopharmacists in GES patient care has never been evaluated.

This study has several limitations. First, the small cohort size of 40 patients may limit the generalizability of the findings. Second, the lack of involvement from a gastroenterologist in the medication review process might affect the comprehensiveness and accuracy of the medication adjustments. Third, the inclusion of all patients regardless of their medication status or comorbidities introduces variability that could influence the results. Lastly, as a single-center study, the findings may not be applicable to other settings. Further research with a larger, more diverse population and multidisciplinary input is needed to validate these findings.

Conclusion

In this study, radiopharmacists involvement allowed for the adjustment or correction of report conclusions, thus potentially avoiding misinterpretations. Despite limitations, our findings demonstrate the positive impact of radiopharmacist involvement in GES interpretation taking into consideration the clinical and medication-related aspects of the patients. We systematically integrate this medication review process into our routine practice of GES exams. Nevertheless, standardization of this practice should be undertaken to expand this approach and more accurately assess its impact.

Abbreviations

ATC	Anatomical Therapeutic Chemical
CT	Computed Tomography
GES	Gastric Emptying Scintigraphy
GORD: Gastro	Esophageal Reflux Disease
GP	Gastroparesis
GRI	Gastric Retention Index
IRB	Institutional Review Board
LEHR	Low Energy High Resolution
MBq	Megabecquerel
SFPC	French Clinical Pharmacy Society
SFMN	French Nuclear Medicine Society
SPECT	Single Photon Emission Computed Tomography

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Authors' contributions
SG, DT, BG and PG contributed to the study conception and design. Data were collected by VN, ON, AC and AM. Material preparation and analysis were performed by VN and AC. The manuscript was written by VN and PG. All authors reviewed and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the institutional review board of the Assistance Publique – Hôpitaux de Marseille (IRB number PADS20-269). Informed consent was obtained from all individual participants included in the study.

Consent for publication
Not applicable.

Competing interests
The authors have no relevant financial or non-financial interests to disclose for this article.

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