

# Recognition and Management of Clarithromycin-Induced Non-Vertiginous Dizziness in an Elderly Patient with Pertussis

Enoch Chi Ngai Lim<sup>1</sup>, Chi Eung Danforn Lim<sup>1,2,3\*</sup>

<sup>1</sup>Translational Research Department, Specialist Medical Services Group, Earlwood, Australia

<sup>2</sup>NICM Health Research Institute, Western Sydney University, Westmead, Australia

<sup>3</sup>School of Life Sciences, University of Technology Sydney, Ultimo, Australia

Email: \*chi.lim@westernsydney.edu.au

**How to cite this paper:** Lim, E.C.N. and Lim, C.E.D. (2025) Recognition and Management of Clarithromycin-Induced Non-Vertiginous Dizziness in an Elderly Patient with Pertussis. *Journal of Biosciences and Medicines*, 13, 321-332.

<https://doi.org/10.4236/jbm.2025.139027>

**Received:** August 16, 2025

**Accepted:** September 8, 2025

**Published:** September 11, 2025

Copyright © 2025 by author(s) and Scientific Research Publishing Inc.

This work is licensed under the Creative Commons Attribution-NonCommercial International License (CC BY-NC 4.0).

<http://creativecommons.org/licenses/by-nc/4.0/>



Open Access

## Abstract

An 85-year-old woman developed persistent mild dizziness without vertigo three days after starting clarithromycin 500 mg twice daily for serology-confirmed pertussis. The dizziness did not improve with prochlorperazine and fully resolved within three days of switching to betahistine. Diagnostic workup was unremarkable, including a normal electrocardiogram (with no QT prolongation) and normal basic laboratory tests. In the absence of other causes, clarithromycin was implicated as the likely cause of the patient's dizziness. This case illustrates a rare but important adverse effect of clarithromycin in an older patient, and highlights the need to recognize drug-induced dizziness, differentiate it from other etiologies, and manage it appropriately to ensure both effective treatment of the infection and patient safety.

## Keywords

Clarithromycin, Side Effects, Dizziness

## 1. Introduction

Clarithromycin is a macrolide antibiotic commonly used to treat respiratory infections, including those caused by *Bordetella pertussis* (whooping cough) [1]. It is generally well tolerated, but like other macrolides, it can cause a range of adverse effects. Gastrointestinal side effects, such as nausea, diarrhea, and abdominal pain, are most frequently reported. Less commonly, clarithromycin may affect the central nervous system (CNS) or inner ear, leading to symptoms such as headaches, insomnia, irritability, or dizziness [2]. Although dizziness is reported in <1% of

patients [2], it is a noteworthy adverse effect, particularly in older adults who may be more susceptible to drug-induced balance disturbances [2]. Rarely, macrolides, including clarithromycin, have been associated with ototoxicity (sensorineural hearing loss, sometimes accompanied by tinnitus or vertigo) [2]. Clarithromycin has also been linked to uncommon neuropsychiatric reactions (e.g. confusion, hallucinations, and even akathisia) in case reports [3].

Older patients are at higher risk for adverse drug reactions due to age-related pharmacokinetic changes and polypharmacy [4] [5]. In particular, elderly women have been noted to experience reversible deafness with clarithromycin more often than other groups [5], suggesting age and sex as risk factors for macrolide otovestibular side effects. Given that dizziness in an older person can have many etiologies, ranging from benign inner ear disorders to serious cardiac or neurologic events, recognizing a medication side effect is crucial to avoid misdiagnosis or unnecessary interventions. We report a case of an 85-year-old female who developed non-vertiginous dizziness temporally associated with clarithromycin therapy for pertussis. This case highlights the importance of considering antibiotic side effects in the differential diagnosis of new-onset dizziness, and describes the successful management of the symptoms without interrupting essential antimicrobial treatment.

## 2. Case Presentation

An 85-year-old Asian female with a history of well-controlled hypertension (on angiotensin II receptor blocker (ARB)—candesartan 8mg daily) and osteoarthritis presented to her general practitioner (GP) with an 8-week history of coughing paroxysms. She saw another 4 weeks ago and was prescribed amoxicillin without any improvement. Serological testing confirmed elevated C-reactive protein (CRP) at 35.6 mg/L and ESR at 116 mm/h, as well as pertussis infection. Biochemical tests, including kidney and liver function tests, were normal. The chest X-ray showed no active pulmonary infection. Atypical pneumonia serology, as well as influenza screen, were negative. She was started on clarithromycin 500 mg orally twice daily. Aside from the coughing spells, she was in her usual state of health at the time of treatment initiation, with stable vital signs and no baseline neurological deficits.

### 2.1. Timelines

Three days after the commencement of clarithromycin therapy, she developed intermittent dizziness. She described the sensation as light-headedness and feeling “off balance”, but explicitly denied any vertigo (no spinning sensation or motion illusion) and had no associated nausea, vomiting, or ear symptoms. The timeline of her clinical course is summarized in **Table 1**.

### 2.2. Evaluation

On examination during the dizziness episode at the completion of clarithromycin

**Table 1.** Clinical timeline—symptom onset and resolution.

Day after the commencement of 7-day course of clarithromycin therapy	Clinical event and intervention	Outcome
Day 0	Pertussis diagnosed; clarithromycin 500 mg twice a day started.	Cough present; no dizziness.
Day 3	Mild, intermittent dizziness develops (non-vertiginous).	Clarithromycin continued; pertussis symptoms improving.
Day 6	Patient did not inform the GP about the intermittent dizziness until she completed 7-day course of clarithromycin on the day.	Prochlorperazine 5 mg up to three times a day given for dizziness on as needed basis.
Day 9	Betahistine 16 mg three times a day initiated for 3 days; prochlorperazine stopped.	Prochlorperazine did not improve the intermittent dizziness.
Day 12	Continued clarithromycin and betahistine.	Dizziness fully resolved; cough much improved.

therapy, the patient was alert and oriented. Her blood pressure was 132/78 mmHg supine and 128/80 mmHg standing (no significant orthostatic drop). Heart rate was 76/min and regular. She had no nystagmus and a normal otoscopic exam. Neurological exam was intact: cranial nerves were normal, motor strength was full, Romberg test was negative, and there were no sensory deficits. Gait testing showed a steady gait without ataxia; the patient could walk unaided, which supported her description that the dizziness did not substantially impair her balance. She reported no hearing loss, tinnitus, chest pain, dyspnea or palpitations at any point. Given clarithromycin's known potential cardiac effects, an electrocardiogram (ECG) was obtained. It showed a normal sinus rhythm and a QTc of 431 ms (within normal range, no QT prolongation).

### 2.3. Clinical Course

The working impression was that the patient's dizziness was an adverse effect of clarithromycin, given the temporal association and absence of alternative causes on initial evaluation. The clarithromycin was continued to treat pertussis, as stopping it early could risk treatment failure. The patient was initially treated symptomatically with oral prochlorperazine 5 mg, an antiemetic often used for vertigo. However, this provided no relief. Three days later, prochlorperazine was discontinued and betahistine 16 mg three times daily was started. Over the subsequent 48 - 72 hours, the dizziness steadily improved, and by three days after starting betahistine, the symptom had completely resolved. CRP has returned to normal level five days after the completion of clarithromycin therapy. Her pertussis symptoms continued to improve, and at follow-up, she had no recurrence of dizziness. As a precaution, a Brain MRI/MRA was performed and showed no acute intracranial pathology, apart from age-related chronic microvascular ischemic changes. Formal audiovestibular testing was reserved as a next step if the patient's dizziness had persisted despite empirical treatment with betahistine, which ultimately was

not required given the complete symptom resolution.

### 3. Mechanism of Side Effects

Clarithromycin's association with dizziness can be attributed to its effects on both the central nervous system and the vestibular (inner ear) apparatus. The exact mechanism underlying clarithromycin-induced dizziness is not fully understood, but several contributing factors have been proposed:

#### 3.1. Central Nervous System (CNS) Effects

Macrolides are capable of crossing the blood-brain barrier and may cause neurotoxic effects in susceptible individuals [3]. Clarithromycin in particular has been reported to cause confusion, light-headedness, and even hallucinations in rare cases [3]. These neurotoxic manifestations are thought to be idiosyncratic. One hypothesis is that accumulation of the drug or its active metabolite (14-hydroxy-clarithromycin) in the CNS can lead to transient neurotransmitter imbalances or direct neuronal effects [3]. In our patient, the dizziness (described as light-headedness) without vertigo or focal deficits suggests a central effect, essentially a sense of altered equilibrium or mild cerebral hypoperfusion-like sensation, rather than true vertigo arising from the inner ear. Supporting a central mechanism, clarithromycin's other CNS side effects (e.g. insomnia, mood changes) indicate it can alter neurological function beyond the vestibular system [2]. Notably, older adults may be more prone to such effects, as drug clearance is often reduced with age, leading to higher serum and tissue levels [4] [6].

#### 3.2. Ototoxicity and Vestibular Effects

Macrolide antibiotics, especially erythromycin (at high doses), have long been recognized to cause reversible hearing loss in some patients, often elderly or those with renal/hepatic impairment [4]. Clarithromycin, a semisynthetic derivative of erythromycin, was developed to have fewer gastrointestinal side effects and improved pharmacokinetics [4], but it can still infrequently cause cochlear and vestibular toxicity [2] [4]. Clinical reports have documented clarithromycin-induced sensorineural hearing loss in patients on standard or high doses, with onset usually within a few days of therapy [4]. In many cases (though not all), the hearing loss and any associated tinnitus or disequilibrium are reversible upon stopping the drug [4]. The mechanism of macrolide ototoxicity is not completely understood, but it is hypothesized to involve interference with ionic transport in the stria vascularis of the cochlea or direct damage to cochlear hair cells [4]. Vestibular involvement (manifesting as vertigo or balance disturbance) is less common than auditory symptoms, but vestibular ototoxicity has been observed with other antibiotics (notably aminoglycosides) and, rarely, with macrolides [4]. In this patient, there was no true spinning vertigo or nystagmus, and no hearing change, suggesting that if the inner ear was affected, it was mild. It is possible that clarithromycin caused a transient dysfunction in her vestibular system or brainstem

vestibular nuclei, which produced nonspecific dizziness. The prompt response to betahistidine supports a vestibular component: betahistidine is known to enhance inner ear blood flow and improve vestibular compensation [7], which may counteract subtle vestibular disturbances caused by the drug.

### 3.3. Cardiovascular Factors (Indirect)

Clarithromycin can prolong the cardiac repolarization (QT interval) and precipitate arrhythmias in predisposed individuals [8]. An arrhythmia (such as torsades de pointes) or even marked bradycardia could cause dizziness or syncope due to transient cerebral underperfusion. In our case, this mechanism was unlikely because the patient's ECG showed no QT prolongation or arrhythmia, and she did not experience palpitations or fainting. Nonetheless, the evaluation of any patient with dizziness on clarithromycin should include a cardiac assessment, since QT prolongation and associated arrhythmias are known risks of macrolides [9], especially in older patients or those on concomitant QT-prolonging medications.

In summary, clarithromycin-induced dizziness in this patient was most consistent with a mild neurotoxic or vestibulo-toxic effect of the drug. The patient's advanced age likely contributed to her susceptibility, as drug accumulation or heightened sensitivity in the elderly can amplify such side effects [10]. Fortunately, no permanent damage occurred, consistent with most reported cases where symptoms abate after the drug is cleared [10]. **Table 2** outlines the differential considerations for dizziness in this context, highlighting why clarithromycin's effect was deemed the culprit.

**Table 2.** Differential diagnosis of dizziness in an elderly patient on clarithromycin.

Potential cause	Key findings in this case	Consideration
Clarithromycin adverse effect (CNS or vestibular toxicity)	Onset 3 days after starting drug; known rare side effect; no alternative cause found; symptom resolved after supportive treatment (and completion of therapy).	Likely cause. Idiosyncratic reaction causing dizziness/light-headedness without vertigo. More common in older adults due to higher drug levels.
Clarithromycin-induced arrhythmia (e.g. bradyarrhythmia or torsades de pointes)	ECG normal; no QT prolongation; patient had no palpitations or syncope.	Unlikely. ECG monitoring is essential since macrolides can cause QT prolongation, but this patient showed no evidence of arrhythmia.
Interaction with other medications (leading to hypotension or CNS depression)	Patient's only other medications were an angiotensin II receptor blocker (ARB) (no interaction) and the subsequently given vestibular drugs. No sedatives or hypotensive agents added.	Unlikely. Clarithromycin can elevate levels of certain drugs via CYP3A4 inhibition, but no culprit drugs were present here.

**Continued**

Prochlorperazine side effect (hypotension, sedation)	Dizziness was present before prochlorperazine; no worsening noted with one dose. Blood pressure remained stable.	Unlikely as a primary cause. Prochlorperazine can cause drowsiness and orthostatic hypotension, potentially worsening dizziness in some cases, but here it neither helped nor significantly harmed.
Systemic illness (pertussis infection effects, dehydration)	Patient was improving on antibiotics; no fever or orthostasis; hydration was adequate; labs (electrolytes, hemoglobin) were normal.	Unlikely. Systemic infection or dehydration can cause light-headedness, but the timing (day 3 of antibiotics) and lab findings do not support this.
Primary vestibular disorder (e.g. benign paroxysmal positional vertigo, vestibular neuritis)	No vertigo or nystagmus; dizziness not positional; normal neuro exam; symptom resolved quickly with medical therapy.	Unlikely. Vertigo from BPPV or labyrinthitis was absent. No recent viral illness to suggest neuritis. The presentation closely followed drug initiation instead.
Central neurologic event (e.g. transient ischemic attack, stroke)	No focal neurological deficits; dizziness was continuous (not transient attacks); brain imaging was not indicated given a normal exam.	Unlikely. A stroke in posterior circulation can cause dizziness, but typically with other signs (gait ataxia, cranial nerve deficits) which were absent. The intermittent, mild nature of symptoms and clear temporal link to medication favor a drug effect.

**4. Pitfalls and What to Watch Out For**

This case highlights several pitfalls in evaluating dizziness in an elderly patient on antibiotic therapy, as well as important considerations to ensure a safe outcome:

**4.1. Attributing Dizziness to “Old Age” or Infection**

It could be tempting to dismiss mild dizziness in an 85-year-old as a nonspecific symptom of illness or aging. However, doing so may overlook a medication side effect. In this instance, the strong temporal association between starting clarithromycin and onset of dizziness raised suspicion of a drug effect. Clinicians should maintain a high index of suspicion for medication side effects whenever a symptom coincides with the initiation of a new drug, even in an older patient who may have other reasons for dizziness. Careful history-taking is critical to distinguish pre-existing balance issues from new-onset dizziness following drug initiation.

**4.2. Missing Serious Underlying Causes**

Conversely, not every dizziness complaint on an antibiotic is due to the drug. A key pitfall is anchoring on the medication and failing to evaluate other causes. In an elderly patient, causes like cardiac arrhythmias, orthostatic hypotension, med-

ication interactions, or stroke must be considered and reasonably ruled out. In our patient, an ECG was appropriately obtained to check for QT prolongation or arrhythmia, given clarithromycin's known cardiac risks [8] [9]. Vital signs and orthostatic blood pressures were measured to exclude significant hypotension. Her normal neurological exam helped exclude a central lesion. Thus, a thorough workup prevented misdiagnosis of a potentially serious condition such as a transient ischemic attack. Clinicians should "trust but verify", while a drug side effect was suspected, verifying normal cardiac and neurologic status was essential before ascribing the symptom to clarithromycin.

### 4.3. Prochlorperazine Use in Non-Vertiginous Dizziness

One management pitfall was the initial use of prochlorperazine. Prochlorperazine is a vestibular suppressant and antiemetic commonly used for acute vertigo or migraine-associated dizziness. In this case, the patient's dizziness was not true vertigo, and she had no nausea. As expected, prochlorperazine provided no relief; indeed, its sedative and hypotensive effects can sometimes exacerbate light-headedness in older patients. Additionally, prochlorperazine (a dopamine antagonist) can cause extrapyramidal side effects or delirium in the elderly. In retrospect, using prochlorperazine in this scenario was a relatively low-yield intervention. The pitfall is using a one-size-fits-all approach to dizziness; it's essential to differentiate between vertigo and non-vertiginous dizziness (such as presyncope or general imbalance), as the treatments differ. If the clinical picture is not consistent with vestibular vertigo, medications like prochlorperazine or meclizine may not be beneficial and could cause side effects.

### 4.4. Not Recognizing Clarithromycin's Neurotoxic Potential

Macrolides are not typically the first drugs that come to mind for CNS side effects, so clinicians might not immediately link clarithromycin to new dizziness or confusion. This case demonstrates that although uncommon, clarithromycin can cause significant CNS symptoms (dizziness in our patient, and as literature notes, sometimes confusion, hallucinations or even mania [3]). Failing to recognize this could lead to unnecessary consultations or investigations (for example, ordering MRI scans or referring to neurology) when the remedy might simply be drug discontinuation. Clinicians should be aware of the neuropsychiatric side effect profiles of antibiotics; for instance, beta-lactams can cause seizures in patients with renal impairment, fluoroquinolones can cause agitation or neuropathy, and macrolides, such as clarithromycin, can cause dizziness or delirium [3].

### 4.5. Polypharmacy and Interactions

Another consideration is clarithromycin's role as a potent CYP3A4 inhibitor [11]. In an elderly patient on multiple drugs, clarithromycin can raise levels of co-medications leading to toxicity (e.g. benzodiazepines, warfarin, statins). For example, if our patient had been on a benzodiazepine, increased levels could have caused

sedation and dizziness. Or if on a calcium-channel blocker, clarithromycin could precipitate hypotension and dizziness by elevating those drug levels. A pitfall would be failing to review the patient's medication list for potential interactions. Fortunately, she was on minimal other medications in this case. Nevertheless, medication reconciliation and interaction checking are "must-do" steps when prescribing clarithromycin to older patients. This also extends to contraindicated co-administrations (e.g. clarithromycin with certain arrhythmia drugs or with colchicine, which in the elderly can be fatal).

#### **4.6. Monitoring and Follow-Up**

Once an adverse effect is suspected or identified, close monitoring is important. In this case, the patient was followed up within a few days to ensure the dizziness resolved after the interventions. A potential pitfall is lack of follow-up, which could be dangerous if, for instance, the symptom worsened or heralded a more serious development. Additionally, the care team advised the patient to avoid driving or high-risk activities while dizzy, emphasizing fall prevention. This is crucial because any dizziness in the elderly poses a fall risk, something that should always be counseled and mitigated (e.g. use of a cane or assistance, removing fall hazards at home) while managing the issue.

### **5. Management**

Managing adverse drug effects in an older patient requires balancing the urgency of treating the primary illness with the need to alleviate harmful side effects. In this case, the primary illness was pertussis, which requires a full course of appropriate antibiotics both to treat the patient and to reduce transmission. Clarithromycin is one of the first-line agents for pertussis [1], and given this patient's allergy profile and the need for prompt therapy, clarithromycin was the chosen antibiotic. When she developed dizziness, the management approach involved several steps:

#### **5.1. Symptomatic Treatment**

Prochlorperazine was first tried, albeit without benefit. The more effective measure was initiating betahistine, an antivertigo medication. Betahistine's mechanism involves both histamine H1 agonist and H3 antagonist activity, leading to vasodilation in the inner ear and improved vestibular function [7]. It facilitates vestibular compensation and can reduce the severity of dizziness and vertigo in disorders of the inner ear [7]. In our patient, betahistine 16 mg TID was well tolerated and coincided with a complete resolution of dizziness within a few days. Notably, betahistine is generally safe in the elderly; it has no sedative effects and a low side-effect profile (occasional headache or mild gastric upset) [12]. Using betahistine allowed the patient to remain comfortable and active while completing antibiotic therapy. An important point is that betahistine was used empirically; the patient did not have a confirmed vestibular diagnosis, such as Ménière's disease, but given

the suspicion of a labyrinthine component to her dizziness, betahistine was a reasonable off-label choice. Its success in this case suggests that even when dizziness is not classic vertigo, if a drug-induced vestibular dysfunction is suspected, betahistine may be beneficial.

## 5.2. Risk-Benefit Assessment of Antibiotic Continuation

Once it was suspected that clarithromycin was causing the dizziness, one management option could have been to discontinue or switch to an alternative antibiotic. Alternative agents for pertussis include azithromycin (another macrolide) or trimethoprim-sulfamethoxazole [1], as shown in Table 3. Stopping clarithromycin at Day 3, however, might have left her infection undertreated. Azithromycin, while given for fewer days, has a similar side effect profile (and has its own rare reports of dizziness or even arrhythmias) [13]. Switching to trimethoprim-sulfamethoxazole was an option if the dizziness were severe, but that drug carries other risks in the elderly (renal effects, hyperkalemia). In Australia, cost is also a significant consideration, as clarithromycin is Pharmaceutical Benefits Scheme (PBS) subsidized for pensioners, whereas azithromycin is not, making clarithromycin a more accessible and affordable option for older patients. Generally, if an adverse effect is tolerable or can be managed with adjunct therapy (and is not dangerous), continuing the primary treatment is preferred. If the side effect had been severe (e.g., disabling vertigo or a serious reaction like an arrhythmia or delirium), immediate discontinuation of clarithromycin would have been warranted. Indeed, literature on clarithromycin neurotoxicity recommends prompt withdrawal of the drug if significant CNS symptoms occur, which usually leads to full resolution of symptoms within a week [3].

**Table 3.** Comparison with alternative pertussis regimens.

Regimen	Duration	Advantages	Limitations in Elderly Patients	Cost/Access in Australia
Clarithromycin 500 mg twice a day for 7 days	7 days	Effective, widely available, PBS-subsidised	Rare neuro/CNS adverse effects (as in this case)	Covered under Pharmaceutical Benefits Scheme (PBS), low cost for pensioners
Azithromycin 500 mg Day 1, then 250 mg daily for 4 days	5 days	Shorter duration, similar efficacy	Can prolong QT, rare dizziness/arrhythmia reports	Not PBS-subsidised, higher out-of-pocket cost
Trimethoprim-Sulfamethoxazole (TMP-SMX) 160/800 mg twice a day for 14 days	14 days	Alternative in macrolide-intolerant patients	Risk of renal dysfunction, hyperkalemia, cytopenias	PBS-listed but less favourable safety profile in elderly

## 5.3. Monitoring and Support

Older patients experiencing dizziness should be counselled on fall-risk precautions, including the use of support when walking, avoiding driving, and ensuring a safe home environment until symptoms resolve. Throughout her treatment course, the patient was closely monitored. She was advised on safety measures: to

rise slowly to avoid any orthostatic dizziness and to have assistance for ambulation until symptoms resolved, considering her fall risk. Family members were informed about the potential side effects so they could help observe and ensure compliance with the betahistine. Fortunately, no additional interventions were needed as her dizziness abated. It is worth noting that if dizziness had persisted even after completing clarithromycin, further evaluation (such as audiovestibular testing or brain imaging) would have been considered to rule out other causes. In our patient, this was unnecessary because the timeline of resolution matched the expectation for a drug side effect (improvement as the drug was cleared from her system).

#### **5.4. Reporting and Documentation**

This adverse reaction has since been documented in the patient's medical record as a likely clarithromycin-induced dizziness. While not an absolute contraindication for future use, it signals caution if clarithromycin (or related macrolides) must be used again. The patient was counseled that in any future course of similar medication, she should report early if dizziness or related symptoms recur. Formal reporting to pharmacovigilance systems (e.g. Australia's Therapeutic Goods Administration's pharmacovigilance inspection program [14] or the United Kingdom's Yellow Card scheme [15]) can be considered for unusual or impactful drug reactions; doing so contributes to the knowledge base on drug safety. Given that dizziness with clarithromycin is already recognized but uncommon, individual reporting is discretionary; however, raising awareness among colleagues (as in this case report) serves to educate clinicians about managing such side effects. It is also important to note that this report is limited by its single-case design, the absence of serum clarithromycin level monitoring, and the lack of objective dizziness scales to quantify symptom severity. These factors limit generalizability but highlight the need for continued clinical vigilance and research into macrolide-related neurotoxic effects.

#### **6. Conclusion**

This case illustrates the successful management of a rare side effect of a commonly used antibiotic. An 85-year-old woman developed non-vertiginous dizziness as an adverse reaction to clarithromycin therapy for pertussis. Through careful assessment, other serious causes of dizziness were excluded. Symptomatic treatment with betahistine led to the prompt resolution of the dizziness, allowing completion of the necessary antibiotic course. The case stresses the importance of vigilance for medication side effects in the elderly, who are often more susceptible to drug toxicity. Clinicians should be aware that clarithromycin, beyond its usual gastrointestinal side effects, can occasionally induce CNS or vestibular disturbances. Early recognition of such side effects, a thorough differential diagnosis (ruling out cardiac or neurologic etiologies), and appropriate management, whether through adjunct therapies or modification of the drug regimen, are crucial. By balancing



Substrate and Various Enzymatic Sources Including a New Cell-Based Assay with Freshly Isolated Human Hepatocytes. *Drug Metabolism Letters*, **4**, 69-76.

<https://doi.org/10.2174/187231210791292717>

- [12] Murdin, L., Hussain, K. and Schilder, A.G. (2016) Betahistine for Symptoms of Vertigo. *Cochrane Database of Systematic Reviews*, **2016**, CD010696. <https://doi.org/10.1002/14651858.cd010696.pub2>
- [13] Ray, W.A., Murray, K.T., Hall, K., Arbogast, P.G. and Stein, C.M. (2012) Azithromycin and the Risk of Cardiovascular Death. *New England Journal of Medicine*, **366**, 1881-1890. <https://doi.org/10.1056/nejmoa1003833>
- [14] Therapeutic Goods Administration (2022) Report Adverse Events for Medicines and Biologicals. Australian Government Department of Health. <https://www.tga.gov.au/how-we-regulate/monitoring-safety-and-shortages/report-adverse-events-medicines-and-biologicals>
- [15] Medicines & Healthcare Products Regulatory Agency (n.d.) Yellow Card—Making Medicines and Medical Devices Safer. <https://yellowcard.mhra.gov.uk>