CASE REPORT WITH FOCUSED REVIEW · WORKING PAPER

Refractory Ventricular Fibrillation in Out-of-Hospital Cardiac Arrest: Electrical Escalation or Time to Extracorporeal Resuscitation?

A prehospital resuscitation case with eight unsuccessful defibrillations and the question of the optimal escalation strategy

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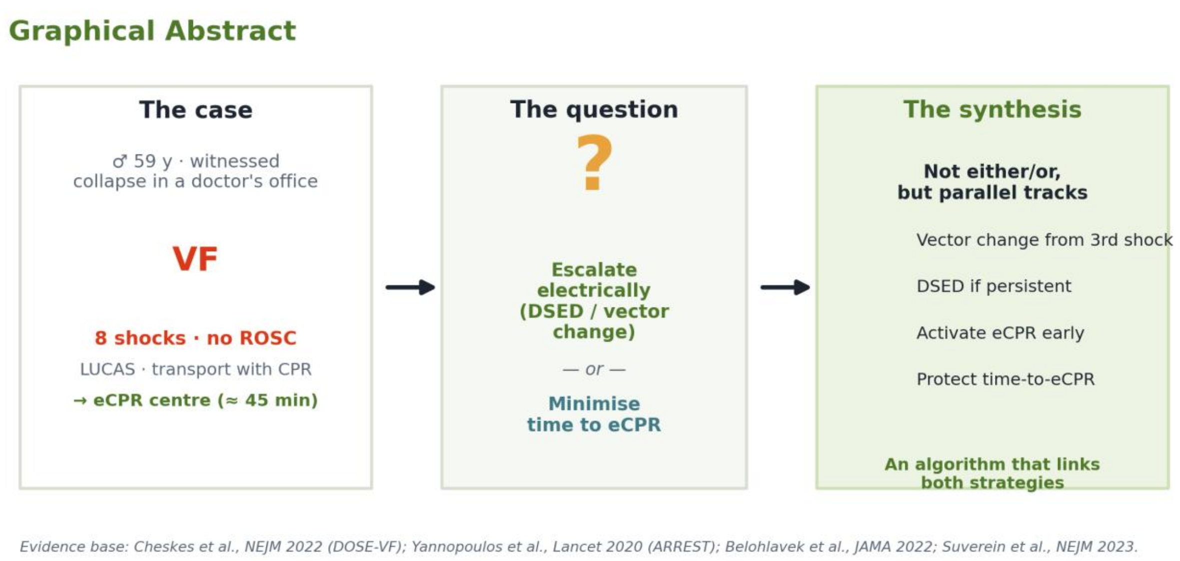
IN BRIEF

In refractory ventricular fibrillation, two modern strategies compete for the same scarce resource – time: **on-scene electrical escalation** (vector change, double sequential external defibrillation) and **rapid transport to extracorporeal cardiopulmonary resuscitation (eCPR)**. Using a case with eight unsuccessful defibrillations, this report shows that the two are not mutually exclusive but can be combined as parallel treatment tracks.

HIGHLIGHTS

- Refractory ventricular fibrillation (persistence after ≥ 3 defibrillations) calls for escalation beyond standard defibrillation.
- The DOSE-VF trial demonstrates a survival benefit for vector change and double sequential external defibrillation (DSED) over the standard strategy.[2]
- eCPR can improve neurologically favourable survival in selected patients but is highly time-critical.[4,5]
- On-scene escalation and eCPR should be pursued **in parallel**, not sequentially – neither must delay the other.



Graphical Abstract. The case (refractory ventricular fibrillation, eight unsuccessful shocks, transport to eCPR), the central question (escalate electrically vs. minimise time to eCPR), and the proposed synthesis of parallel treatment tracks.

SUMMARY

Background: Refractory ventricular fibrillation (rVF) in out-of-hospital cardiac arrest carries a poor prognosis under conventional advanced life support. Two developments have changed prehospital care: alternative defibrillation strategies (vector change, double sequential external defibrillation) and extracorporeal cardiopulmonary resuscitation (eCPR). However, both compete for the same scarce resource – time. **Case:** A 59-year-old man collapsed in a witnessed manner in a doctor's office; the initial rhythm was ventricular fibrillation. Despite high-quality resuscitation, eight defibrillations, airway management, and amiodarone and epinephrine per algorithm, ventricular fibrillation persisted throughout. Under mechanical resuscitation (LUCAS), the patient was transported for eCPR; handover at the receiving centre occurred about 45 minutes after dispatch with ventricular fibrillation still present. **Discussion:** The case illustrates four practice-relevant decisions – the number of defibrillations and epinephrine doses, empirical antiplatelet therapy and anticoagulation, vector change, and double sequential external defibrillation. From the current evidence, a prehospital algorithm is derived that combines electrical escalation and eCPR as parallel tracks. **Conclusion:** In refractory ventricular fibrillation, the constructive stance is not “escalation or eCPR” but “escalation and timely eCPR”.

Keywords: out-of-hospital cardiac arrest · refractory ventricular fibrillation · double sequential external defibrillation · vector change · extracorporeal cardiopulmonary resuscitation (eCPR) · emergency medicine

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) remains one of the most time-critical emergencies in prehospital medicine. In Germany, the incidence of EMS-treated cases is estimated at roughly 50–60 per 100,000 population per year; an initially shockable rhythm – ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) – is present in about one fifth of patients and is associated with a comparatively better prognosis (ERC guidelines 2021).[1] The prerequisite is rapid, high-quality resuscitation with early defibrillation.

In a subset of these patients, however, ventricular fibrillation cannot be terminated by repeated standard defibrillations. This is termed **refractory ventricular fibrillation** (rVF), usually defined as persistence or recurrence of VF after at least three adequate defibrillations.[1,2] Under purely conventional advanced life support (ALS), this constellation has a poor prognosis.

Two developments have shaped the management of refractory VF in recent years. First, **alternative defibrillation strategies** – changing the shock vector axis (vector change) and double sequential external defibrillation (DSED) – showed a marked survival benefit in the randomised DOSE-VF trial (Cheskes et al., NEJM 2022).[2,3] Second, **extracorporeal cardiopulmonary resuscitation (eCPR)** can improve neurologically favourable survival in selected patients with refractory arrest, although the evidence from randomised trials is heterogeneous.[4,5,6] Both strategies draw on the resource that is scarcest in cardiac arrest: time. Every additional on-scene measure potentially delays transport to eCPR – and vice versa.

This case report describes a prehospital resuscitation with persistently refractory ventricular fibrillation and uses the questions raised during the in-hospital debriefing as a starting point to discuss this conflict in light of the current evidence and to propose a practicable algorithm.

CASE REPORT

Dispatch. At 09:17, the emergency-physician unit (NEF) was dispatched to an ongoing resuscitation: a 59-year-old man in a doctor's office. With an approach distance of about 5 km, the approach was used to agree on the strategy (mechanical resuscitation device LUCAS, transport with ongoing resuscitation as a possible option). On arrival of the emergency physician at 09:27, the ambulance (RTW) crew was already on scene; the first rhythm analysis was performed by the ambulance team.

On-scene situation. Resuscitation was ongoing, performed by the ambulance crew and practice staff in the stairwell of the practice. The first analysis showed ventricular fibrillation; the ambulance team had already defibrillated. The attending physician reported that the patient had collapsed without a word immediately after entering the practice – without breathing or pulse; the emergency call had been made and basic life support started immediately. The patient's history included arterial hypertension and hyperlipidaemia; coronary artery disease was not known. Initial airway management with a laryngeal mask was insufficient, and the first peripheral venous access attempt failed.

Advanced life support. After a structured situation assessment, the algorithm for shockable rhythms was followed consistently: epinephrine and amiodarone after the third shock; establishment of intraosseous access (as peripheral access had failed and the ambulance crew was less experienced with the i.o. route, NEF paramedics and ambulance paramedics performed this jointly), followed by endotracheal intubation by the emergency physician and paramedic. Ventilation was delivered in a pressure-controlled mode; the end-tidal CO_2 was about 12 mmHg. The reversible causes (4 Hs and HITS) were worked through; a cardiac or thromboembolic origin emerged as the leading suspicion.

Decision for eCPR and transport. As ventricular fibrillation recurred despite continued resuscitation (fourth and fifth shock, again 150 mg amiodarone and 1 mg epinephrine), eCPR was announced via the dispatch centre and an eCPR-capable centre was activated. Given suspected cardiac ischaemia, ASA 300 mg and heparin 5000 IU were administered. After the LUCAS device was applied and a fire-and-rescue vehicle arrived to assist with carrying, the patient was transported through the stairwell; in the ambulance, ventricular fibrillation recurred (sixth shock).

Course until handover. During transport, ventricular fibrillation persisted throughout (seventh and eighth shock), and epinephrine was continued per algorithm. The end-tidal CO_2 remained consistently above 10 mmHg, ventilation was with FiO_2 1.0; peripheral oxygen saturation was around 80% with a poor signal, with no clinical cyanosis. Handover in the cardiac catheterisation laboratory of the receiving centre took place about 45 minutes after dispatch, with ventricular fibrillation still present (Figure 1). The further in-hospital course is beyond the scope of this report.

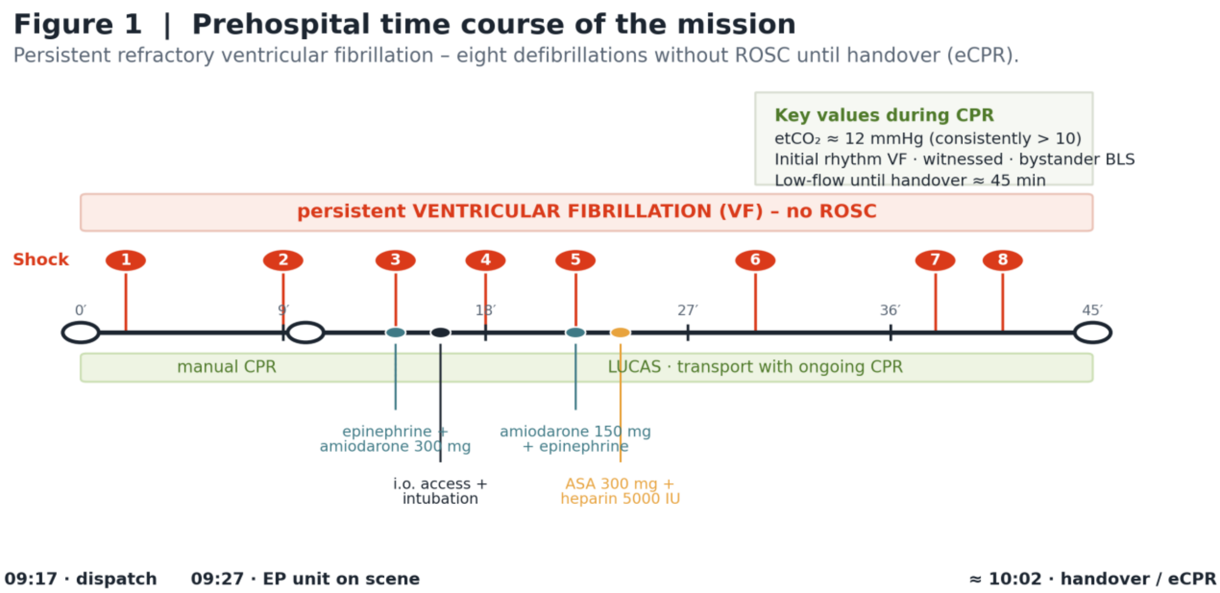


Figure 1. Prehospital time course from dispatch (09:17) to handover for eCPR (≈ 10:02). Refractory ventricular fibrillation was present throughout the mission; eight defibrillations did not achieve return of spontaneous circulation (ROSC). Marked are defibrillations (red), pharmacological and airway measures, and mechanical resuscitation and transport with ongoing CPR. Times partly rounded or estimated.

DISCUSSION

What does “refractory” mean?

There is no single definition of refractory ventricular fibrillation; the literature usually uses persistence or recurrence after three adequate defibrillations, alternatively after about ten minutes of unsuccessful resuscitation or after administration of epinephrine and amiodarone.[1,2] Clinically, the exact threshold matters less than the insight that simply “carrying on” with unchanged standard defibrillation becomes increasingly unlikely to succeed as the shock count rises. This is precisely where escalation strategies come in.

Defibrillation strategy: vector change and double sequential external defibrillation

The key clinical question of this case is whether electrical therapy should have been escalated in the face of persistent ventricular fibrillation. The **DOSE-VF trial** (Cheskes et al., NEJM 2022) randomised 405 patients with refractory VF in clusters to three strategies: standard defibrillation (antero-lateral), **vector change** (repositioning to antero-posterior), and **double sequential external defibrillation (DSED)** with two defibrillators and rapidly successive shocks.[2] Survival to hospital discharge rose from 13.3% (standard) through 21.7% (vector change) to 30.4% (DSED); neurologically favourable survival was likewise highest with DSED (Figure 2). For DSED versus standard, the relative risk of survival was 2.21 (95% confidence interval 1.33–3.67).[2] These results confirmed and refined the previously published pilot study (Cheskes et al., Resuscitation 2020).[3]

Physiologically, the benefit is attributed to an altered and – for DSED – overall higher transmyocardial current density that depolarises previously refractory myocardium. Several points are important for practice: vector change requires no additional equipment and can be implemented immediately, and should therefore be considered early in persistent VF. DSED requires a second defibrillator and a well-rehearsed team; the near-simultaneous shock delivery is off-label from the device perspective, and possible device damage cannot be entirely excluded. Despite the convincing evidence, DSED therefore depends on local protocols, equipment, and training. In the present case – with persistently refractory VF across eight shocks – this escalation option was rightly raised in the debriefing.

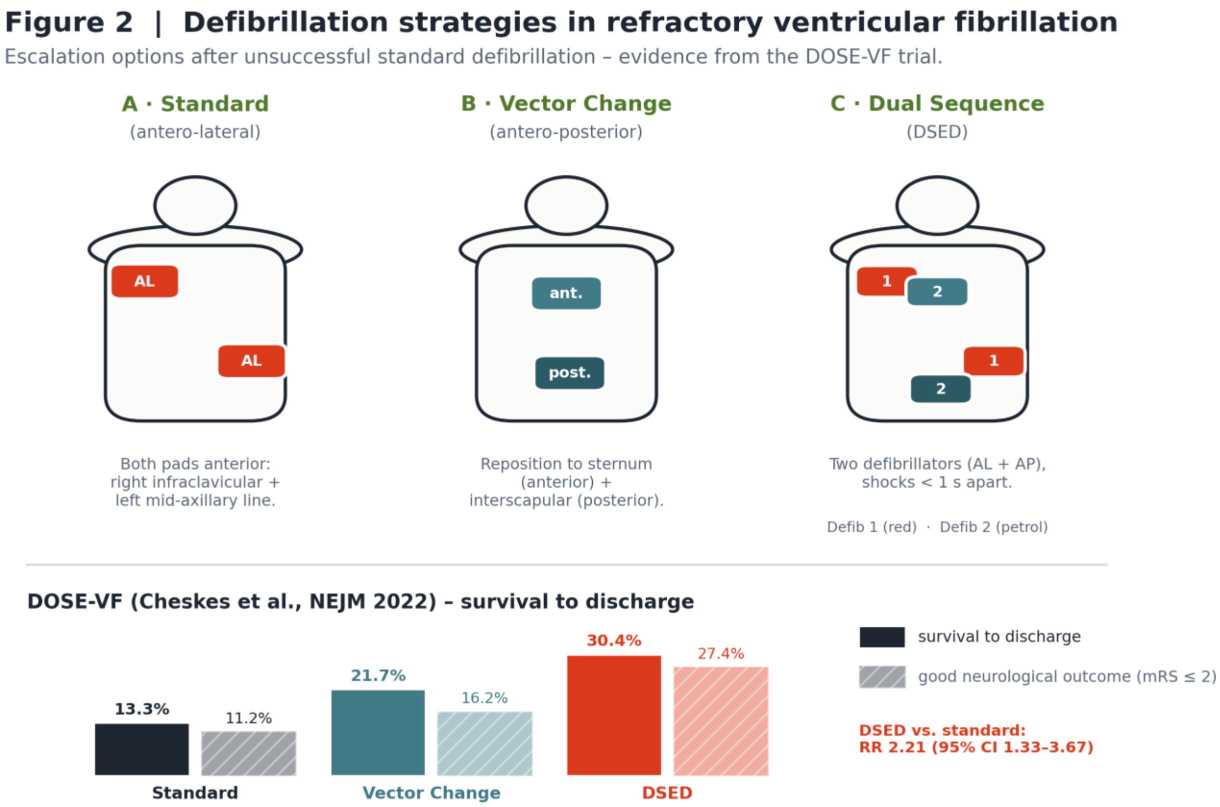


Figure 2. Defibrillation strategies in refractory ventricular fibrillation. (A) Standard antero-lateral, (B) vector change to antero-posterior position, (C) double sequential external defibrillation (DSED) with two defibrillators. Bottom: survival to discharge and good neurological outcome (modified Rankin Scale ≤ 2) by strategy in the DOSE-VF trial.[2]

Antiarrhythmics and epinephrine – how much is useful?

The debriefing raised the question of the appropriate number of epinephrine and defibrillation doses. In the ALPS trial (Kudenchuk et al., NEJM 2016), amiodarone produced a numerically but not significantly higher survival rate versus placebo; a benefit was most apparent in witnessed arrest.[8] In the PARAMEDIC2 trial (Perkins et al., NEJM 2018), epinephrine improved the rate of return of spontaneous circulation and 30-day survival without reliably increasing neurologically favourable survival.[7] In refractory VF, the marginal benefit of repeated high-dose epinephrine is therefore uncertain; guidelines (ERC 2021) recommend continuation at the established intervals (1 mg every 3–5 minutes).[1] In the present case, dosing followed the guideline. More important than the exact number of doses is the consistency with which reversible causes and escalating strategies are pursued in parallel.

Empirical antiplatelet therapy and anticoagulation in suspected ischaemia

The prehospital administration of ASA 300 mg and heparin 5000 IU for suspected cardiac ischaemia is understandable but only weakly evidence-based – particularly during ongoing resuscitation and with planned eCPR. The current ESC guideline on acute coronary syndromes (Byrne et al., Eur Heart J 2023) recommends **against routine pretreatment with a P2Y$_{12}$ inhibitor** while the coronary anatomy is unknown; ASA is part of acute therapy, and the optimal timing of anticoagulation depends on the invasive strategy.[10] In a patient taken directly for cannulation and possibly coronary intervention, early heparin is on the one hand plausible (thrombus, impending catheter/cannula thrombosis) but on the other increases the bleeding risk at the large-bore cannulation sites. The decision should therefore ideally be made in coordination with the receiving eCPR centre and not reflexively.

eCPR: indication, evidence and time window

eCPR bridges refractory cardiac arrest by means of veno-arterial extracorporeal membrane oxygenation until a treatable cause – usually coronary ischaemia – can be addressed. The evidence is heterogeneous:

the single-centre **ARREST** trial (Yannopoulos et al., Lancet 2020) was stopped early for superiority of eCPR (survival to discharge 43% vs. 7%).[4] The **Prague-OHCA** study (Belohlavek et al., JAMA 2022) narrowly missed its primary endpoint (neurologically favourable survival at 180 days) but showed signals favouring the invasive approach.[5] The multicentre **INCEPTION** trial (Suverein et al., NEJM 2023) found no significant difference between eCPR and conventional resuscitation, albeit with longer time intervals and organisational challenges under trial conditions.[6] Taken together, the patients most likely to benefit are **selected** ones: witnessed arrest, initially shockable rhythm, bystander CPR, short low-flow time (often < 60 minutes to cannulation), and surrogate markers of still-adequate perfusion such as an end-tidal CO_2 above 10 mmHg. With a witnessed collapse, VF as the initial rhythm, and a consistently maintained $etCO_2 \approx 12$ mmHg, the present patient met several of these criteria.

The time conflict: on-scene escalation versus load-and-go

This brings the core of the case discussion into focus: every additional minute of on-scene care potentially improves the chance of terminating the fibrillation – but also lengthens the low-flow time to eCPR. Conversely, a sole focus on rapid transport forgoes the opportunity for a potentially successful escalation. A large observational study (Grunau et al., JAMA 2020) showed that **intra-arrest transport** was, on average, associated with worse survival than continued on-scene resuscitation.[9] This finding does not argue against eCPR, however, but against transport as a mere “fallback” without a destination: in the eCPR candidate, transport is precisely the definitive therapy.

The resolution therefore lies not in an “either/or” but in **parallelisation**. Vector change and – where available – DSED cost almost no time on scene and should be fully exploited, while the eCPR track is activated simultaneously (pre-alert, mechanical resuscitation, carrying assistance, transport logistics). If ventricular fibrillation remains refractory despite maximal escalation, rapid transport under mechanical resuscitation to the eCPR centre is the logical step. Figure 3 summarises this approach as a prehospital algorithm.

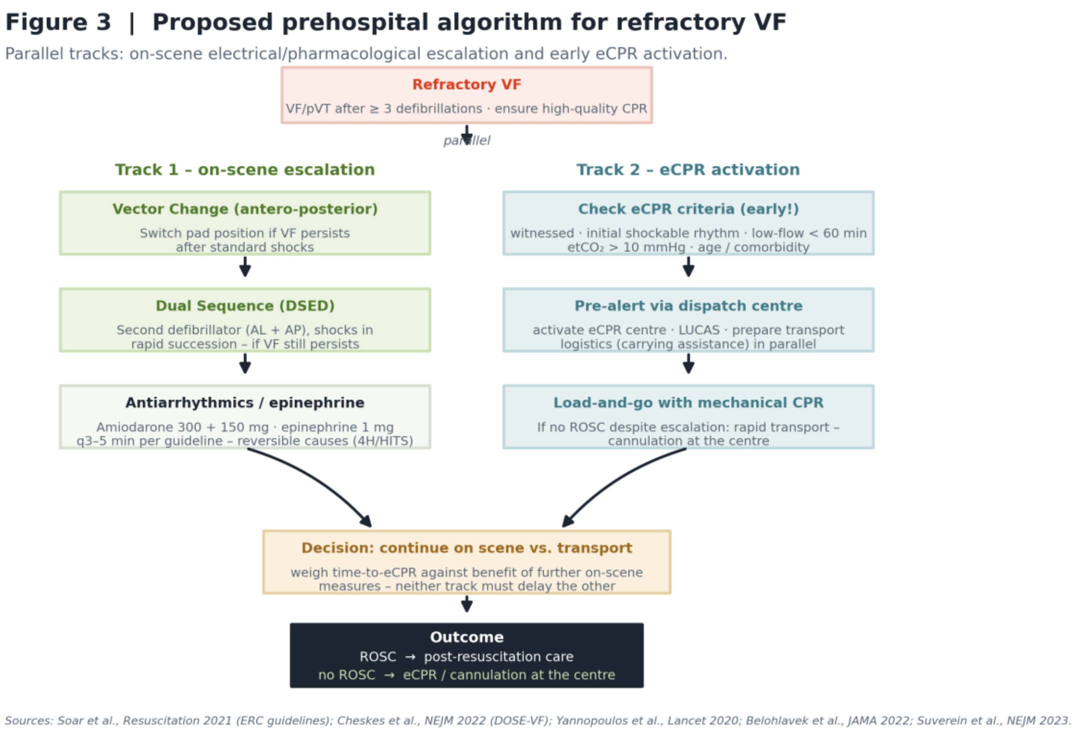


Figure 3. Proposed prehospital algorithm for refractory ventricular fibrillation. On-scene electrical-pharmacological escalation (Track 1) and eCPR activation (Track 2) run in parallel; the subsequent “continue on scene vs. transport” decision is guided by time-to-eCPR. Neither track must delay the other.

Limitations

This is a single, retrospectively prepared case without long-term follow-up data; no causal conclusions can be drawn from it. The cited evidence is heterogeneous (single- vs. multicentre trials, different systems and time intervals), and the transferability of DSED and eCPR depends strongly on local equipment, training, and centre affiliation. The proposed algorithm is intended as a structuring aid, not a rigid prescription, and does not replace the applicable regional protocols.

CONCLUSION

The case of persistently refractory ventricular fibrillation with eight unsuccessful defibrillations brings together the central decisions in the modern management of refractory VF. The evidence suggests escalating standard defibrillation early when VF persists (vector change, and DSED on further refractoriness) while activating the eCPR track in good time. What matters is the stance: not "electrical escalation **or** eCPR" but "escalation **and** timely eCPR" – two parallel tracks that do not delay but complement each other.

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DECLARATIONS

Conflicts of interest: The author declares no conflicts of interest. **Funding:** This work received no external funding. **Ethics and consent:** This is an anonymised case report; patient-identifying details have been removed.

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