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Carbon footprint of diagnostic coronary angiography

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Environmental concerns related to global warming impact all sectors of society, with healthcare contributing approximately 5% of global greenhouse gas (GHG) emissions – making it the 5th largest emitting entity on the planet. Annually, around 5 million cardiac catheterisation procedures are performed worldwide. Despite this, the healthcare sector is lagging in efforts to reduce GHG emissions, and there is a lack of detailed studies that accurately estimate the emissions generated by specific procedures[1]. Ditac et al reported that atrial fibrillation catheter ablation results in an average of 76.9 kg of carbon dioxide (CO_2)-equivalent (CO_2e) emissions, amounting to 125 tonnes of CO_2e released daily[2]. Unfortunately, no studies have evaluated the carbon footprint of coronary angiography procedures. This work aims to estimate the overall and detailed carbon footprint of a coronary angiography procedure, with the goal of raising awareness among healthcare professionals and industry partners to reduce the GHG emissions associated with these procedures.

To conduct this study, we exhaustively catalogued all the equipment and treatments used during a standardised diagnostic coronary angiography procedure at our centre. After this, we analysed each product, detailing its manufacturing material, country of origin, and primary packaging, while also measuring the weight of each item. We also considered the type of waste disposal (hazardous medical waste or general waste). The same process was applied to the treatments. Once the inventory was completed, all data were integrated into different calculators, which allowed us to establish the carbon footprint of each product. For medical devices, the calculator used was provided by the French Agency for Ecological Transition (ADEME) website. This calculator includes the entire lifecycle of a medical device, from the origin of all raw materials to the end-of-life of the device, including all transportation between different stages. We only considered the device and its primary packaging. For medications, the calculator used was provided by Ecovamed, which considers all stages of a medication's lifecycle (active ingredient, primary and secondary packaging, and end of life). The emission factor of the active ingredient was calculated based on the price of the active ingredient per kilogram, which was then multiplied by an economic emission factor depending on the country of production (EXIOBASE).

The total carbon footprint associated with the products used during a diagnostic coronary angiography procedure amounts to 8 kg of CO_2e. The total carbon waste for the treatment process, which includes the disposal and management of used materials, contributes an additional 4.48 kg of CO_2e (~35%) **(Supplementary Table 1)**. Energy consumption during a single procedure is estimated at 1.3 kWh, which corresponds to approximately 0.078 kg of CO_2e in France, where electricity generation is largely based on nuclear energy. Each intervention generates 2.869 kg of waste (621 g of packaging and 2,248 g of medical devices). An analysis of each procedural category reveals that most emissions arise from single-use consumables (31%) and surgical drapes/covers (40%), while medications, disinfection, and energy consumption play a comparatively smaller role **(Table 1)**.

The total carbon impact of a coronary angiography procedure is estimated to be 12.56 kg of CO_2e. This highlights the significant environmental impact of such routine medical practices and underscores the importance

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Table 1. Carbon footprint summary by procedural category.

Category	Total carbon footprint (kg of CO_2e)	Waste management carbon footprint (kg of CO_2e)	% of total	Key reduction opportunity	
Medications & anaesthesia	3.10	0.03	~25%	Simplify agents	Policy, accreditation standards, and financial incentives
Consumables/tools	3.93	1.44	~31%	Switch to reusables or low-impact materials	
Disinfection	0.41	0.17	~3.3%	Use refillable packaging, low-impact agents	
Drapes & covers	5.04	2.84	~40%	Reduce drape use; bundle smarter packs	
Facility energy consumption	0.078		~0.6%	Energy efficient devices/ sustainable energy management/ reduce procedure duration	
Total	12.56	4.48			

of considering sustainability in healthcare procedures[3]. One area for improvement is the composition of the angiography kit provided. It would be beneficial to review the kit's contents to eliminate surplus devices that do not add value to the procedure but contribute significantly to the carbon footprint. Regarding iodine, using larger-volume vials that can be shared among multiple patients would not only reduce the carbon footprint but also provide an economic benefit to healthcare facilities. Attention must be given to the end-of-life management of all medications and medical devices. Establishing recycling pathways and collaborating with specialised waste management companies could significantly improve the environmental footprint. In addition to material and waste reduction, emerging strategies such as remote diagnostic approaches may further reduce the carbon footprint of cardiovascular procedures and warrant future investigation. Finally, regulatory and institutional frameworks – such as green procurement policies, sustainability-linked accreditation criteria, and reimbursement incentives – could play a pivotal role in encouraging hospitals to adopt low-carbon practices in procedural care.

This study presents some limitations. The calculations do not take into account the exact formulation or manufacturing processes for the medications, including factors such as yield or energy consumption in the production facilities. These data are not provided by pharmaceutical laboratories, making it impossible to incorporate them into the analysis. Similarly, for medical devices, the manufacturing process is not considered, as these details are subject to industrial confidentiality and are therefore unavailable for inclusion in the calculation. Some data were not available or not shared by the manufacturers. We chose not to include emissions from transportation and broader hospital logistics due to the significant variability of these factors depending on patient origin, staff travel modes, and institutional supply chains, which are often difficult to generalise across settings

The carbon footprint of a diagnostic coronary angiography procedure is estimated at 12.56 kg of CO_2e. This value is derived from various sources, including the use of medical materials, energy consumption and waste management. Several areas for improvement are identified, which could significantly reduce the carbon footprint of such cardiac procedures.

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Conflict of interest statement

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Supplementary data

Supplementary Table 1. Breakdown of the carbon footprint of a diagnostic coronary angiography procedure.

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Supplementary data

Supplementary Table 1. Breakdown of the carbon footprint of a diagnostic coronary angiography procedure.

Product Name	Country of Manufacture	Material	Material Weight	Packaging	Packaging Weight	End-of-life type	Carbon Footprint Production (KgCO2e)	Carbon foot print Waste (KgCO2e)
Anesthesia								
Droperidol	Germany	Droperidol	1,25mg	Glass	2g	HMW	0.072	0,00026
Midazolam	Germany	Midazolam	5g	Glass	4g	HMW	0.073	0,00052
Sufentanil	France	Sufentanil	50 ug	Glass	6g	HMW	0.039	0,00078
Lidocaine 1% (10mg/ml)	France	Lidocaine	100 mg	PE	3g	HMW	0.066	0,00831
Operating Room								
Cupule 120ml	Portugal	PP	5g	Paper wrap, LDPE	7g	GW	0.044	0,025
Hypodermic Needle 25GX16mm	Spain	PP, Stainless Steel	1g	Paper wrap, LDPE	3g	HMW	0.009	0,00831
Cardio Kit	Mexico	PTFE, Nylon	78g	Paper wrap, LDPE	14g	GW	0.316	0,25
Introducer 5F Radial with Metal Needle	China	PP, Stainless Steel	25g	Paper wrap, LDPE	11g	GW	0,118	0,072
Coronary Angiography Catheter DXterity™ Ultra	Mexico	Polyamide, Stainless Steel	90g	Paper wrap, LDPE	50g	GW	0,43	0,23
Diagnostic Guide	Ireland	PP, Stainless Steel	50g	Paper wrap, LDPE	10g	GW	0.029	0,013
Tissue Cotton Border	China	Cotton	20g	Paper wrap, LDPE	8g	GW	0,34	0,029
Radial Compression Bracelet 24cm	China	PEHD	30g	Paper wrap, HDPE	10g	GW	0,12	0,1
Surgical Gloves	Thailand	Polyisoprene	22g	Flexible plastic	6g	GW	0.0765	0,067
Disinfection								
Betadine Solution 5% (500ml)	France	Povidone Iodine	25g	LDPE, HDPE, PET	100g	HMW	0.024	0,011
Compress (Cotton, 30g, 7.5x7.5cm)	Portugal	Viscose, Polyester	3g	Paper wrap, PP	5g	GW	0.0254	0,015
Sodium Chloride 0.9% (1000ml)	France	Sodium Chloride, PP	9g	PP	40g	HMW	0.33	0,11
Medication								
Heparin Choay Solution (5,000UI/ml)	Germany	Heparin Sodium, Glass	1g	Glass	4g	HMW	0,84	0.00052
Isosorbide Medisol Injection (10mg/10ml)	France/Switzerland	Dinitrate Isosorbide, Glass	10mg	Glass	6g	HMW	0,85	0,00078
Iomeron Solution (350mg/200ml)	Italy	Iodine, Glass	700 mg	Glass	120g	HMW	1.07	0,0156
Angiography Kit								
Paper Crepe 60x60cm	Czech Republic	Cellulose	20.5g			GW	0.0958	0,051
Adhesive Field Primary 90x75cm	China	PE	48.4g			GW	0.223	0,13
Adhesive Field 45x75cm	Czech Republic	PE, Viscose	22.2g			GW	0.157	0,055
Gauze Compress (10x10cm)	China	Cotton	18g			GW	0.327	0,045
500ml Blue Bowl	Czech Republic	PP	17.5g			GW	0.0682	0,048
2500ml Blue Bowl	China	PP	79.2g			GW	0.414	0,22
60ml Red Cup	Portugal	PP	6g			GW	0.0369	0,016
Surgical Scalpel	United Kingdom	Stainless Steel, PS, PEBD	7g	PP	62g	GW	0.0318	0,019
Hypodermic Needle 21G 40mm	China	PP, Stainless Steel, PE	1g			HMW	0.00841	0,0027
Syringe 10ml L	Spain	PP, Isoprene	6.2g			GW	0.0323	0,017
Syringe 10ml LL	China	PP, Isoprene	7.6g			GW	0.0434	0,021
Syringe 20ml Excentrically	China	PP, Isoprene	14.3g			GW	0.0777	0,039
Amplifier Cover 107x97cm	China	PE	80g			GW	0.373	0,22
Amplifier Cover 127cm	China	PE	44.2g			GW	0.205	0,12
Surgical Gown	Cambodia	Nylon, PP, PE	153.9g			GW	1.08	0,42

Product Name	Country of Manufacture	Material	Material Weight	Packaging	Packaging Weight	End-of-life type	Carbon Footprint Production (KgCO2e)	Carbon foot print Waste (KgCO2e)
Hand Towel 47x38cm	United Kingdom	Cellulose	14.4g			GW	0.0682	0,035
Reinforced Tablecloth 150x190cm	Czech Republic	PE, PP	250g			GW	0.129	0,1
Angiography Field 240x365cm with 4 Openings	Czech Republic	PE, Viscose	672g			GW	4.08	1,86
ECG Electrodes with Pressure	N/A	PE, Stainless steel	1,08g	Opaque plastic	70,92g	GW	0,0631	0,016
Anios Gel 85 NPC	France	Ethanol, Water, Glycerin	495g	PP	79g	GW	0,0055	0,044
TOTAL			**2248g**		**621g**		**12,48**	**4,48**

GW - General Waste
HDPE - High-Density Polyethylene
HMW - Hazardous Medical Waste
LDPE - Low-Density Polyethylene
PET - Polyethylene Terephthalate
PP - Polypropylene
PTFE - Polytetrafluoroethylene