Energy and Cost Savings Obtained with a Modified Pancreas MRI Protocol in Defined Clinical Settings

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An abbreviated MRI protocol for surveillance of Intraductal pancreatic mucinous neoplasms (IPMN)

- Surveillance of IPMNs, typically with MRI, represents a **growing demand on resources** but there is a need for imaging departments to deliver more **sustainable healthcare.**
- Standard pancreas MRI (P-MRI) includes contrast enhanced sequences.
- Studies have shown that abbreviated protocols which omit gadolinium are suitable for detecting worrisome features or high risk stigmata without malignancy being missed. This is supported by a retrospective evaluation performed at our institution, a quaternary pancreatic referral centre.
- An **abbreviated protocol** for follow up of low risk suspected or confirmed IPMNs (A-MRI) which **omits contrast enhanced sequences** and includes T2 weighted, T1 and DWI was introduced at our institution with time and cost benefits.
- **The aim of this study was to quantify the environmental effects of performing A-MRI as compared to P-MRI using Life Cycle Assessment.**

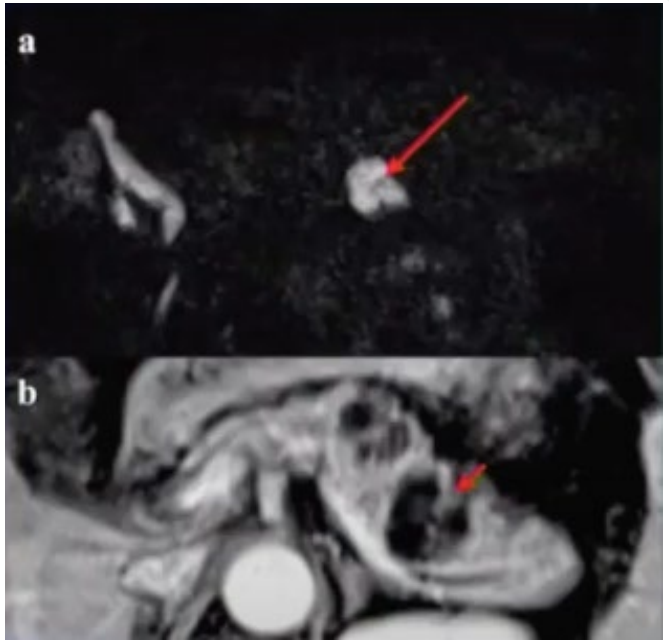

Figure 1a non contrast coronal T2 image of the pancreas showing IPMN with solid component and figure 1b contrast enhanced T1 axial image showing enhancement of the solid component in keeping with thickened enhancing wall- a worrisome feature which was evident on non-contrast images.

Delaney FT et al*., J Magn Reson Imaging. 2021; 54: 1385-1366.*
Tanaka M et al., *Pancreatology*. 2017; 5:738-753.

Life Cycle Assessment

- **Life cycle assessment** (LCA) is a systems based method for quantifying the **environmental impact** of a product or process over its **entire life cycle.**
- LCA provides **information to decision makers** that can guide choices in selecting materials, products, or energy sources.
- The four phases of LCA as outlined by the **ISO LCA Standard** are as follows:

1. **Goal and Scope Definition**
   - Intended application, reasons for carrying out the study, audience and whether the results will be used in comparative assertions released publicly.
   - Product system, functional unit, system boundaries and inventory and impact assessments to be studied.
2. **Inventory Analysis**
   - Collection and documentation of data
3. **Impact Assessment**
   - Transforms simple results such as energy use to impacts such as global warming.
4. **Interpretation**
   - Puts results into perspective and makes recommendations.

H. Scott Matthews et al., *Life Cycle Assessment: Quantitative Approaches for Decisions that Matter.* 2014.

Creating our LCA

Goal

- To quantify the environmental effects of performing A-MRI as compared to P-MRI. Findings were intended to be used locally and disseminated amongst the broader radiology community.

Scope

- The **product system** was defined by creating **process maps** for both P-MRI and A-MRI and identifying **resources used for P-MRI but not A-MRI.**
- The **functional unit** was defined as one diagnostic quality MRI for the follow up of pancreatic IPMN.
- The **inventory data** to be collected included **energy** and **materials** saved by A-MRI.

Inventory Analysis

- Estimates of **energy consumed** by each protocol were calculated using available published data and based on **total time actively scanning** as well as time in **idle and ready to scan** states.
- Items in the **materials inventory** were collected and their constituent parts weighed.

Impact Assessment

- The savings in **energy** and **materials** were used as input to a life cycle assessment (LCA) using SimaPro software.
- The “ReCiPe 2016 Endpoint” methodology was used to **quantify environmental benefits** of AMRI compared to P-MRI.

MR Pulse Sequences and Associated Time

P-MRI

Sequence	Time (m:s)
Loc BH	0:58
Loc FB	0:36
Ax HASTE	1:12
Cor HASTE SLAB	0:05
Ax DWI	4:46
Cor FS SPACE TR	5:40
Cor HASTE	0:52
Ax VIBE DIXON	0:18
Ax T2 FS BH BL	2:17
Radial HASTE	2:11
Ax FS VIBE	0:18
Ax FS VIBE DYN	5:29

A-MRI

Sequence	Time (m:s)
Loc FB	0:18
Loc BH	0:18
Ax DWI	4:04
Ax VIBE DIXON	0:18
Ax HASTE	1:12
Cor HASTE SLAB	0:05
Cor FS SPACE TR	4:52
Cor HASTE	0:44

Materials Associated with Gadolinium Administration

- Gloves
- Cardboard kidney dish
- Tourniquet (single use)
- Alcohol wipe x 5
- Canula
- 10 cc saline flush
- Tubing
- Adhesive dressing
- Gadolinium (single puncture multiple use within 24 hours)
- Disposable MRI kit for injector system
- 100 cc bag N saline Gauze

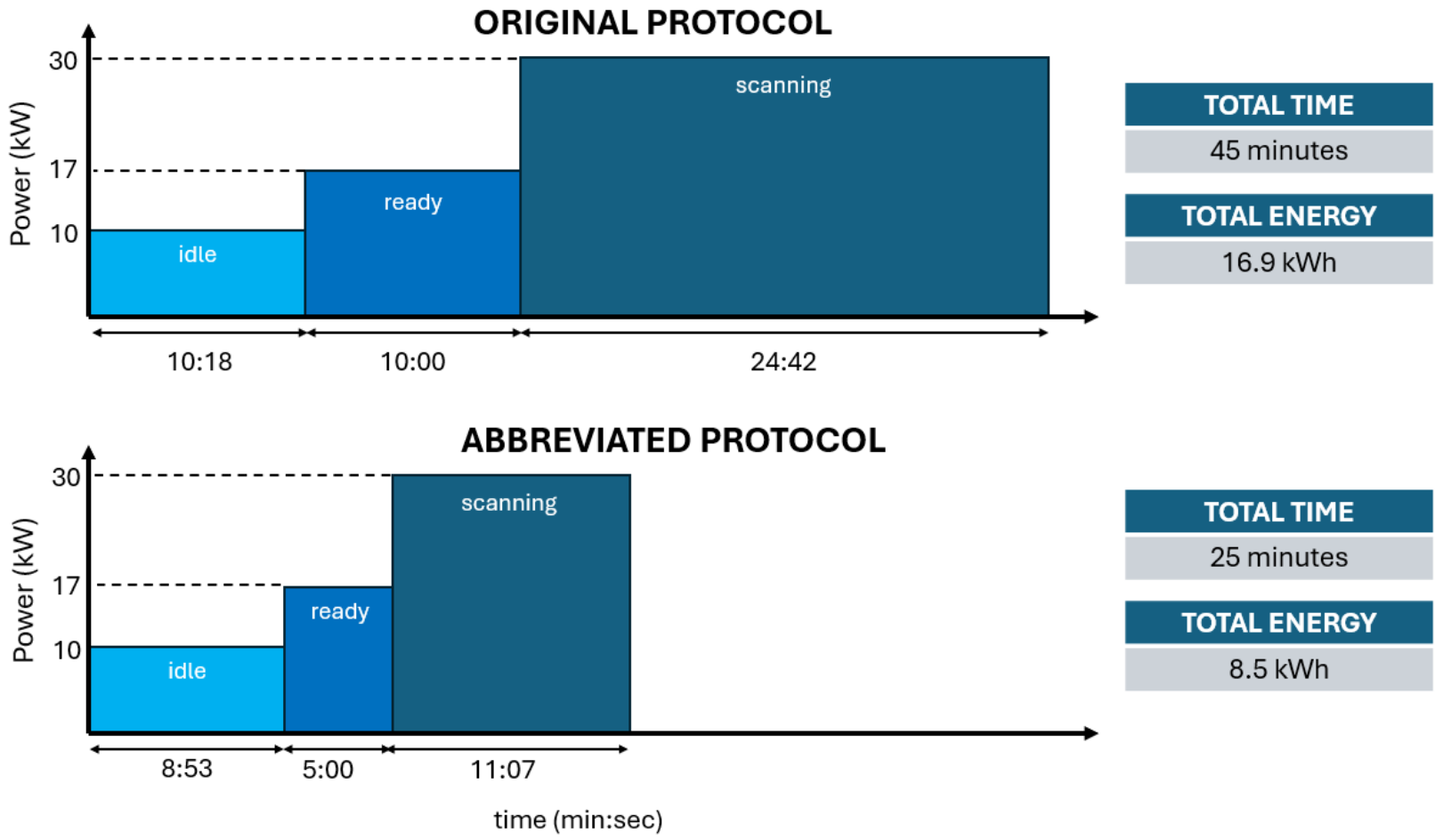

Figure 2 shows time taken and energy used during P-MRI and A-MRI.

Power estimates in idle, ready, and scanning modes from YV Chabin et al., *J. Magn Reson Imaging*, *59(4), 2024.*

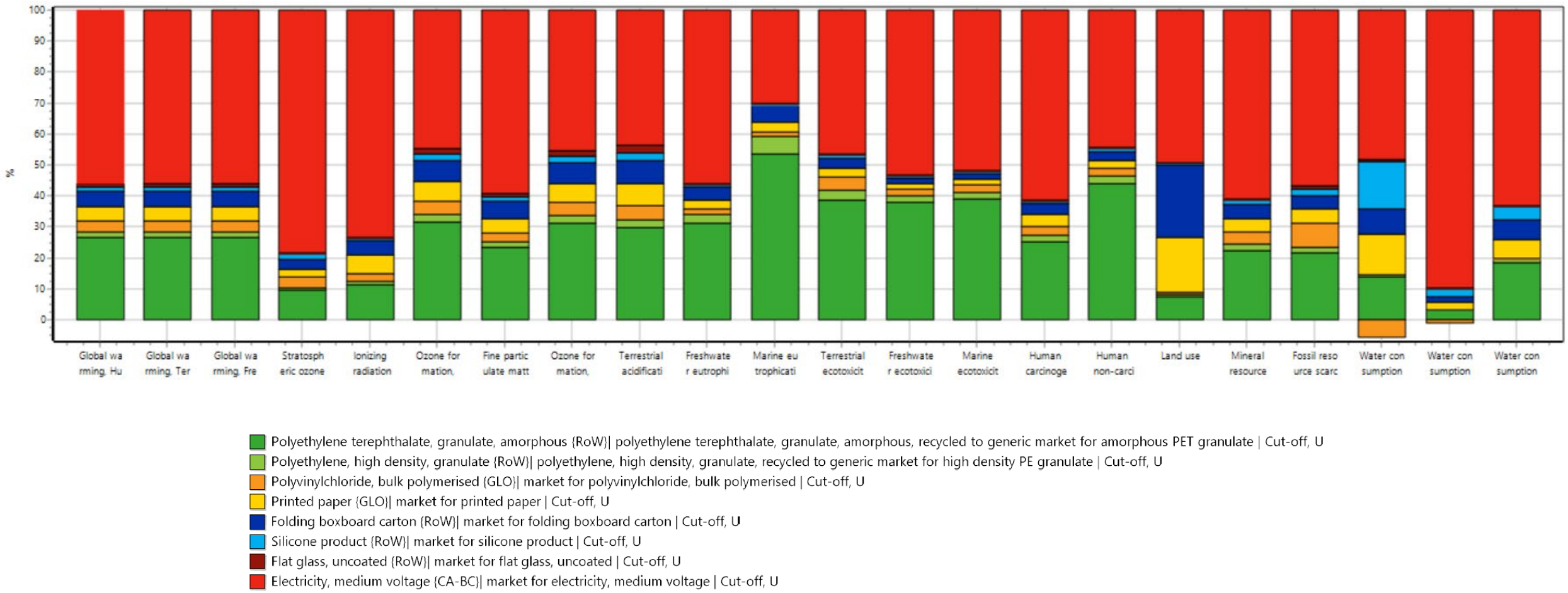

Figure 3. LCA results show the impact on 22 environmental harm categories of performing P-MRI instead of A-MRI.

Relative contribution of energy consumption is shown in red and of material consumption is shown in various other colours.

In our study, the impact of material consumption is of the same magnitude as energy consumption. This owes to the fact that electricity in our region is generated from ~95% renewable sources. When the model is recomputed using data specific to the US, including electricity generated through burning of fossil fuels, environmental impact is dominated by energy consumption.

Co-Benefits of A-MRI

	P-MRI	A-MRI	Savings/Benefit
Active scan time	24:42 minutes	11:07 minutes	**13:35 minutes scan time save**
Booking slot	45 minutes	25 minutes	**20 minutes appointment time save**
Available time slots	Daytime hours	Any time	**Scan anytime 24/7, improves access, reduced wait time**
Cost to administer gadolinium	$64.16	$0	**$64.16 CAD equipment cost savings**
Energy Expenditure	16.9 kWh	8.5 kWh	**8.4 kWh saved**
Cost of Energy Expenditure	$3.25	$1.62	**$1.63 CAD saved**

Average cost of electricity in Canada from www.energyhub.org

Limitations

- Calculations regarding energy expenditure of MRI are based on available published data.
- Gadolinium could not be accounted for in our LCA as it is not available in the SimaPro database.
  - Gadolinium (Gd) is a rare earth metal extracted from minerals using chemicals and heat.
  - Gd chelates used in MRI are excreted via the kidneys with 98% excreted within 24 hours post injection.
  - Gd is not removed by municipal waste management systems.
  - Gd is an increasing contaminant of waterbodies such as ground water, lakes and tap water and the full effects of this are not currently known.

Chaban YV et al., *J Magn Reson Imaging.* 2024; 59(4):1149-1167.

Conclusion

A-MRI for surveillance of IPMNs which has been shown to be safe and effective **reduces environmental effects** through decreased consumption of energy and single-use materials.

Co-benefits include lower costs, more flexible scheduling and improved patient comfort through shorter scan times and the avoidance of cannulation.