INTERVENTIONAL RADIOLOGY: GLOBAL LANDSCAPE AND COST EFFECTIVENESS
INTERVENTIONAL RADIOLOGY

Interventional radiology (IR) is a subspecialty of radiology that incorporates the use of image guidance to perform minimally invasive diagnostic and therapeutic procedures. Charles Dotter helped launch IR in the 1960’s with the idea that “catheters should replace scalpels.” Today, there are many therapeutic areas where minimally invasive IR treatments have proved to be excellent alternatives to open surgical procedures. Over the past 20 years, the IR subspecialty has expanded exponentially in terms of the variety of therapies available to treat diseases affecting virtually every organ in the body, spanning from treatment of cancer to infertility.

Interventional radiologists are physicians certified in Diagnostic Radiology who have undergone further training to develop expertise in the image guided treatment of their patients. By virtue of their training, interventional radiologists are involved in many aspects of the continuum of patient care including imaging evaluation, clinical assessment, intervention and follow-up. IR is an integral part of all types of patient therapy, ranging from acute trauma treatment to palliative care.

Image guided and minimally invasive procedures performed by interventional radiologists tend to lead to lower complication rates and shorter lengths of stay (LOS) relative to traditional surgical therapies. In addition, the cost of running an IR suite is frequently less than that of an operating room (OR). Based on these principles, this document will outline therapy areas in which IR can improve patient care and drive significant cost savings to the Canadian health care system.

INTERVENTIONAL RADIOLOGY IN CANADA

BACKGROUND

Interventional Radiology has had a presence in Canada since the early days of the subspecialty, and Canadian interventional radiologists have contributed pioneering work in the field.\(^1\),\(^2\) Nevertheless, the overall adoption of IR in Canada has lagged considerably behind that of other industrialized nations. As an example of this trend, Figure 1 shows Canada’s lagging adoption of endovascular peripheral arterial disease (PAD) procedures relative to other developed nations such as the US, Europe and Japan.

**Figure 1: Endovascular PAD Procedures, as a % of Diagnosed Prevalent PAD Population, 2011 and 2016**

![Endovascular PAD Procedures Chart]

Source: Millennium Research Group
Formal organization of IR in Canada dates back to 2000, when Canadian interventional radiologists held a meeting at the US Society of Interventional Radiology (SIR) Annual Meeting in San Diego. The Canadian Interventional Radiology Association (CIRA) was born from this meeting. Since 2000, CIRA has become the national voice for IR in Canada, holding annual scientific meetings, facilitating educational programs and advocating the role of IR in Canadian medicine. In 2013, IR was formally recognized as a subspecialty by the Royal College of Physicians and Surgeons of Canada, joining the ranks of IR in most other Western countries.

The goal of this document is to provide the reader with an understanding of the benefits of IR procedures, and to make recommendations to help improve the adoption of IR in Canada—thus improving the quality and access to health care for Canadians.

**IR Adoption in Canada**

Canada lags behind other countries in the G7\(^1\) in the adoption of patient-friendly, cost saving and lifesaving IR treatment. There are several factors that have led to this lag, as described in Table 1 below. The conclusions and recommendations in Table 1 are discussed in greater detail in the sections that follow.

<table>
<thead>
<tr>
<th>Conclusion</th>
<th>MRG’s Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Health care funding in Canada dissuades the adoption of IR</td>
<td>• Canadian government and hospital administrators should revise the system of budget allocation towards IR procedures by providing separate funding for these treatments</td>
</tr>
</tbody>
</table>
| 2. Interventional radiologists are overworked, but must dedicate more time to improving their clinical practice | • Canadian hospitals should increase IR support staffing, including nurses, technologists and administrative assistants  
• More interventional radiologists should be trained and hired to keep up with the current and future demands on the IR departments of Canadian hospitals |
| 3. Awareness of IR must improve                                                                       | • CIRA should continue to play an active role in the development of IR in Canada through IR-based education and training  
• CIRA should partner with other physician groups to drive patient and physician awareness of IR |
| 4. IR in Canada will continue to lag compared to the G7 due to challenges in adopting new IR procedures | • Improved budget allocation, increased resources and better awareness will also give interventional radiologists the tools to work with hospital administration and government to bring cutting-edge treatments to Canada |

Source: Millennium Research Group

**Health Care Funding in Canada dissuades the Adoption of IR**

**Conclusion**

Allocating funding for IR procedures is challenging under the annual operating budgets of Canadian hospitals.

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1 The G7 countries include Canada, the US, France, Germany, Italy, the UK and Japan
2
BACKGROUND

In general, healthcare funding in Canada is allocated as an annual budget to each hospital. This is in contrast to the US and Europe, where a diagnosis-related group (DRG) system is used, which has allowed IR procedures to gain greater traction in these regions. In a DRG system, hospitals are reimbursed on a diagnostic code or disease-specific basis, regardless of the intervention that is chosen. This provides an incentive to select the most cost-effective treatment for each patient, which in turn leads to increased patient access to care and less strain on the overall health care system.

The Canadian model of hospital-based health care results in an incentive to minimize total annual costs, rather than the costs associated with each patient. This incentive can limit patient access to care (as described in the example below), contributing to a greater burden on the Canadian health care system. **MRG’s analysis has shown that IR procedures lead to many patient-centered cost savings; however the Canadian health care system does not allow hospital administrators to recognize and take advantage of the value and cost effectiveness of IR.**

Cost-effective decision making in Canada is further hindered by the division of the annual budget among different departments. As described in the example below, cost-effectiveness is difficult to recognize when it spans various departmental budgets. This is a challenge to IR, because IR procedures typically reduce burdens on the OR budget while adding expense to the interventional and diagnostic radiology operating budget. Although the IR expense is typically smaller than the corresponding OR expense, this phenomenon reflects poorly on the annual IR budget.

EXAMPLE

Millennium Research Group’s (MRG) US-based analysis of abdominal aortic aneurysm (AAA) and lower-extremity PAD interventions concluded that the minimally-invasive procedures are significantly less expensive than their surgical counterparts in these indications. **These cost savings are driven by reductions in procedural complications, reduced reliance on the OR and reduced patient LOS.** Furthermore, reduced LOS leads to a reduction in the societal costs of medical procedures, allowing patients to return to work more quickly.

Although these cost savings are quite significant, they do not align with the mission of Canadian hospitals operating under department-specific annual operating budgets, creating several challenges:

- It is difficult for Canadian hospitals to recognize cost savings that occur across-departments, because these savings span multiple budgets. In this example, minimally invasive endovascular aortic repair (EVAR) and PAD interventions cost less when performed outside of the OR. Despite costing less, increased use of the IR lab puts greater strain on the IR budget, which discourages IR use.
- Reductions in procedural costs that arise from a reduced LOS are not well-recognized in Canada’s non-DRG health care system. For example, MRG’s analysis determined that patients receiving EVAR treatment for unruptured AAA are discharged from the hospital almost 7 days sooner on average than patients receiving open repair for the same indication. The cost savings from a 7-day reduction in hospital bed time could be used to treat another patient. However, treatment of another patient during that time would incur an additional cost to the hospital’s annual budget. In this way, cost-saving IR procedures do not appear to save costs from the Canadian hospital administration’s point of view.
Annual budgets are detrimental to cost-effective decision making when it comes to patient access to health care.

RECOMMENDATIONS

Based on the cost-effectiveness conclusions reached in this document, MRG recommends that the Canadian government and hospital administrators revise the system of budget allocation towards IR procedures. Based on the examples of lower extremity PAD and EVAR, government and administration should recognize that increased short-term funding of IR may reduce the long-term burden on the health care system by improving patient access to care. This is causing Canada to miss out on opportunities to save money and reduce hospital bed wait times through adoption of cost-effective IR procedures.

Separate funding should be made available for IR procedures that have demonstrated cost-effectiveness relative to their status quo surgical counterparts, as described in this document. This includes minimally invasive lower extremity PAD procedures, EVAR, and radiofrequency (RF) ablation (please see pages 9, 11 and 13 respectively for more detail).

NEED FOR CLINICAL INVOLVEMENT AND INCREASED STAFFING

CONCLUSION

In order to ensure optimal patient care as well as growth of IR as a physician specialty, interventional radiologists must become more clinical, increase direct referral patterns and rely less on other specialist physicians for longitudinal patient care. This is challenging given a lack of time and resources available for IR.

BACKGROUND

As IR has matured, interventional radiologists have increasingly become involved in the initial clinical evaluation of patients, as well as ongoing follow-up. This continuum of care improves patient treatment overall. Increasingly, IR training programs include a clinical curriculum, which will be integral in the Canadian IR fellowship program currently under development.

Traditionally, interventional radiologists have engaged in procedure-focused practice, which leads to suboptimal patient care. A lack of longitudinal care incorporating interventional radiologists may lead to inappropriate patient suffering or tests. Clinically focused IR allows proper patient management including appropriate IR management, and medical or surgical referral.

It is important that interventional radiologists become more clinical in practice; however there are challenges to the evolution of Canadian IR in this direction. Unfavourable IR remuneration schedules make it challenging for interventional radiologists to participate in clinical evaluation. Furthermore, IR departments tend to be understaffed, leaving little time for clinical pursuits. Currently, administrators in Canada are reluctant to finance hiring clinical assistants such as nurse practitioners, clinical nurse educators, and assistants to support clinical activities in IR. Additionally, there is a lack of clinic space and infrastructure in IR for patient consults and follow-up visits. These factors are large contributors to Canada’s lag in IR adoption relative to other G7 countries. An increase in IR resources and staffing is required to drive growth in IR while maintaining
the caseload of valuable and cost-saving IR procedures such as drainage, vascular access, and GI bleed embolization.

**Recommendations**

**Canadian hospitals should increase IR support staffing, including nurses, technologists, and administrative assistants.** Increased support would allow interventional radiologists to better manage the time constraints of adopting an increased clinical role, while allowing IR procedures to expand beyond the current caseload.

**More interventional radiologists should be trained and hired to keep up with the current and future demands on the IR departments of Canadian hospitals.** This involves increased enrollment in IR fellowships, which can be driven through promotion and raising awareness or the subspecialty to medical schools by CIRA, supported by a government-led initiative to increase IR positions in Canada. Alleviation of the detrimental factors that dissuade radiologist residents from specializing in IR should also be considered as part of a strategy to increase interventional radiologist enrolment and drive growth in IR procedures. Generally, there is very little exposure to Radiology in medical schools, with only scant information for IR. Interventional radiologists who are affiliated with a medical school should work with CIRA to engage the medical school and encourage the formal adoption of IR into the curriculum.

**Referring Physician and Patient Awareness of IR Must Improve**

**Conclusion**

Referring physician and patient awareness of IR must be improved in order to drive growth of the specialty.

**Background**

**Patient awareness of IR in Canada is quite poor.** Even more concerning is that awareness of IR in the general medical community is not nearly as strong as it could be. It is necessary that referring physicians have a keen understanding and awareness of the value of IR to their patients if IR is to reach its potential effectiveness in Canada. Progress has been made by CIRA to build the "brand" of IR through advocacy and education. In 2013, a survey of family physicians indicated that 53% had an adequate knowledge of IR, and 16% had a good-to-excellent knowledge. This recognition demonstrates that progress has been made, but that there is a long way to go in terms of educating referring physicians about the role of IR.

This concern is not unique to Canada—poor referral patterns limit IR procedure volumes in many countries, hindering the adoption of key procedures, or taking treatments out of the hands of interventional radiologists. **Because IR is a relatively emergent field in Canada, there is a greater opportunity to improve awareness and referral patterns.**

**Example**

Improved patient awareness or referral patterns could drastically increase the number of uterine fibroids patients that are treated using minimally-invasive uterine fibroid embolization (UFE), which is performed by interventional radiologists. As described below (see page 19) UFE is an extremely patient-friendly alternative to hysterectomy, but many gynaecologists do not discuss this option with their uterine fibroid patients. Because
many women consider UFE a more desirable procedure than the surgical treatments for uterine fibroids, a well-informed patient may well choose UFE over hysterectomy for the treatment of symptomatic fibroids.

**RECOMMENDATIONS**

**CIRA should continue to play an active role in the development of IR in Canada.** IR-based education, marketing and training should be targeted at general practitioners (GP) and hospital administrators to increase awareness of IR and the value that it brings to Canadian health care. Educational marketing should also be targeted to patients to increase their awareness of IR treatments and the patient benefits associated with these procedures. **MRG also recommends that CIRA work with industry to drive awareness,** because industry has a stake in many IR procedures, and a greater marketing budget. Canadian patients would benefit from an improved understanding of the minimally-invasive options available to them; this is particularly true for procedures with historically poor referral such as UFE (see page 19).

Finally, CIRA should work with multidisciplinary physician groups to develop best practices (similar to the Canadian Hepatocellular Carcinoma (HCC) Consensus panel described in the Interventional Oncology section below (see page 14) that result in the creation of effective referral patterns.

**CANADA FACES CHALLENGES IN ADOPTING NEW IR PROCEDURES**

**CONCLUSION**

IR in Canada will continue to lag compared to the G7 countries due to challenges in adopting new treatments.

**BACKGROUND**

The challenges facing IR in Canada, as described in the previous sections, create many barriers to entry for innovative IR procedures. A driving principle of IR is innovation, and Canadian interventional radiologists are eager to bring therapies that are available elsewhere in the world to Canada.

Physicians are often left frustrated by the challenges associated with bringing new innovative treatments to Canada; Interventional radiologists interviewed by MRG feel that change is particularly difficult in Canadian hospitals compared to the rest of the G7. In Canada, adoption of new procedures is frequently dictated by the financial constraints of annual hospital budgets and the structure of said budgets, as opposed to the effectiveness (both clinical and financial) of the procedure. It is challenging for individual hospitals to be leaders in adopting new treatments when funding is not made available at the provincial or federal level.

In order to persuade hospitals to adopt new procedures, interventional radiologists must work closely with hospital administration and regional health authorities to prove the value of the procedure and assess the impact that it will have on the hospital budget. While this is a necessary step, it is extremely time-consuming in Canada—interventional radiologists interviewed by MRG estimate that this typically takes more than five years to come to fruition. Furthermore unfavourable IR remuneration and busy schedules do not afford interventional radiologists much time or incentive to dedicate to non-procedural pursuits.
Interventional radiologists must also dedicate time to establishing referral patterns and buy-in from other physician groups when attempting to introduce new minimally invasive therapies.

**Examples**

RF ablation for the treatment of HCC is an IR procedure that is only beginning to achieve widespread availability in Canada, despite having been available in the US, Europe, and Japan for many years. This outpatient procedure can often be performed in place of surgical resection, a major undertaking for both the patient and treating surgeon. Interventional radiologists interviewed by MRG note that developing a hospital-based program to provide this therapy was a significant challenge, taking an average of five years to achieve.

Examples of IR therapies that have shown efficacy and achieved adoption in other countries, but have limited availability in Canada include: radioembolization for the treatment of liver cancer; as well as drug-eluting stents (DES) and drug coated balloons (DCB) for the treatment of lower extremity PAD.

**Recommendations**

In addressing concerns related to currently-available IR treatments, MRG believes that hospital administration departments will be in a better position to recognize and assess the value of new IR treatments. Improved budget allocation, increased resources and better awareness will also give interventional radiologists the tools to work with hospital administration and government to bring cutting edge treatments to Canada.
KEY FINDINGS BY THERAPY AREA
MRG, a Decision Resources Group company, conducted an analysis of eleven key IR therapies to determine the value that IR treatment brings to both patients and the health care system. Additionally, a cost analysis of minimally-invasive IR therapy relative to the surgical alternative was conducted for three therapy areas including: lower extremity PAD, AAA repair, and interventional oncology for HCC. For the cost analysis, US Medicare claims records were analyzed for hospital charges, as well as patient metrics such as LOS, complications and mortality. For all eleven therapies, MRG will suggest IR-driven strategies to improve health care in Canada. The following therapies are included:

- Lower extremity peripheral arterial disease (PAD)
- Endovascular aortic repair
- Interventional oncology
- Vascular access
- Emergency embolization
- Drainage
- Gastrostomy
- Uterine fibroid embolization
- Hemodialysis access maintenance
- Carotid artery stenting
- Thoracic endovascular aortic repair

LOWER EXTREMITY PERIPHERAL ARTERIAL DISEASE (PAD)

ANALYSIS AND KEY FINDINGS
Endovascular treatment of lower extremity PAD can yield superior clinical outcomes compared to surgical disease management. MRG’s analysis of US hospital claim records showed that PAD patients who received endovascular treatment fared better with respect to mortality and complications than patients who underwent surgical bypass. Endovascular patients were also discharged from the hospital sooner.

MRG conducted an analysis of US patient billing records for patients that received endovascular treatment or surgical bypass for the treatment of PAD. This analysis demonstrated that endovascular therapy for the treatment of lower extremity PAD was an average of $6,000 less expensive per patient compared to surgical bypass. Much of the savings is realized because a high proportion of endovascular PAD procedures are performed as outpatient cases, thus reducing in-hospital patient management costs. By treating appropriately-selected PAD patients using endovascular techniques, Canadian hospitals could save a substantial amount of money per patient. Increased use of endovascular treatment also increases access to care by reducing the average LOS thereby freeing hospital beds and allowing more Canadians to receive medical treatment.

2 All dollar values in $USD
Table 2: Comparison of Endovascular Repair and Surgical Bypass for Treatment of Lower Extremity PAD

<table>
<thead>
<tr>
<th>Measure</th>
<th>Endovascular Repair</th>
<th>Surgical Bypass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complication rate</td>
<td>9.2%</td>
<td>18.9%</td>
</tr>
<tr>
<td>Mortality rate</td>
<td>0.7%</td>
<td>1.6%</td>
</tr>
<tr>
<td>LOS (days)</td>
<td>1.9</td>
<td>7.1</td>
</tr>
<tr>
<td>Cost</td>
<td>$10,600</td>
<td>$17,400</td>
</tr>
</tbody>
</table>

Source: Millennium Research Group

BACKGROUND

PAD TREATMENT

PAD prevalence is increasing globally, fuelled by increasing rates of obesity and diabetes. The condition affects over 1.3 million Canadians. At present, however, over half of PAD patients remain undiagnosed. PAD is often underdiagnosed because patient and referring physician awareness of the disease is low. Physician societies in many of the G7 countries are heavily invested in physician education programs as a way to increase disease awareness and to promote earlier detection. Increasing disease prevalence and higher detection rates represents a potentially significant burden to the Canadian health care system. If left to progress, PAD adversely impacts patient quality of life and independence, by limiting mobility through pain or amputation. Early detection and cost-effective treatment will be key to managing the burden of PAD.

Advanced PAD that cannot be managed through medication can be treated surgically or using endovascular techniques. Surgical bypass using a native vessel (such as the great saphenous vein) is an effective procedure, but this approach is costly and invasive. Furthermore, in many cases healthy native vessels are unavailable or are required for coronary bypass surgery. Surgical bypass using a synthetic graft is also an option, however this treatment is not generally accepted to result in improved outcomes compared to endovascular treatment. Endovascular treatment is rapidly gaining favour in the G7 countries, driven by its minimally invasive and patient-friendly nature, increasingly favourable clinical data and ongoing technological advancements.

In fact, endovascular treatment is recommended as a first line therapy by the international TASC II guidelines for treatment of specific lesions. TASC II recommends endovascular treatment for two of the four major classifications (based on the lesion classification system outlined in the guidelines), including relatively uncomplicated lesions without heavy calcification. This type of lesion is the primary presentation in a large proportion of the PAD population; accordingly, the TASC II guideline recommendation has driven strong endovascular adoption in many countries.

Endovascular technology continues to evolve. Self-expanding nitinol stents are the most commonly used stents in the lower extremities, and multiple studies have shown progressively higher patency rates with exceptionally low fracture rates. New endovascular technology innovations such as drug-coated technology, chronic total occlusion (CTO) crossing devices, longer stents and atherectomy devices will further boost the applicability of endovascular treatment by expanding the variety of lesions that can be successfully treated using endovascular intervention. Appropriate funding of IR will ensure continued innovation and improved care in this field.

STATE OF ENDOVASCULAR PAD TREATMENT IN CANADA

Endovascular treatment has experienced significant adoption for the treatment of lower extremity PAD in the US and Europe, whereas adoption is significantly lower in Canada. In 2013, the percentage of endovascular
treatments performed relative to the diagnosed PAD patient population was approximately 2% in Canada, compared to 12% in the US, and the 6% European average.

Interventional radiologists invented endovascular PAD procedures and have been the driving force behind their continued evolution. The vast majority of endovascular procedures performed in Canada are performed by interventional radiologists although the proportion performed by vascular surgeons has increased steadily in the past ten years. Endovascular procedures for PAD are technically challenging and appropriate training is essential to safely perform these procedures and ensure adequate outcomes.

In Canada, lower-extremity PAD treatment is funded through annual hospital budgets, as opposed to the DRG-based funding commonly employed in other G7 countries. As described in the Canadian health care funding section (see page 2), this constrains endovascular PAD procedure adoption in Canada, and is the major reason that Canada’s use of endovascular PAD treatments lags behind the G7 average, as illustrated in Figure 2.

![Figure 2: Endovascular PAD Procedures, as a % of Diagnosed Prevalent PAD Population, 2011 and 2016](source: Millennium Research Group)

**CONCLUSION AND RECOMMENDATIONS**

Endovascular treatment should be considered as a first-line treatment for patients with lower extremity PAD. Canada lags behind the US, Europe, and Japan with respect to adoption of endovascular PAD treatment relative to surgical intervention. There is room for substantially expanded use of endovascular techniques within the recommended indications. **Increased adoption of endovascular PAD treatment increases patient access to care by decreasing the average LOS associated with PAD procedures.** This will help reduce wait-times and help PAD patients receive treatment for earlier-stage disease, which may reduce complications and procedural expenses. Expanded use of endovascular therapy is expected to increase limb salvage and thus dramatically improve patient quality of life, particularly in the most severe form of PAD—critical limb ischemia (CLI).

MRG estimates that endovascular PAD procedures cost an average of $6,000 less than comparable surgical bypass procedures. Efforts should be made to increase Canadian adoption of endovascular
PAD procedures as a proportion of the diagnosed prevalent PAD population (2%) to average of the US, Europe, and Japan (9%). Based on MRG’s analysis, it would cost **approximately $145 million less** to treat this potential cohort using endovascular techniques compared to the current surgical techniques.

**ENDOVASCULAR AORTIC REPAIR (EVAR)**

**ANALYSIS AND KEY FINDINGS**

MRG conducted a review of US patient billing records for patients that received EVAR or open repair for the treatment of AAA. Similar to patients treated with endovascular repair for lower extremity PAD, **patients who were treated with EVAR fared better on procedural outcomes such as mortality rate, complication rate, and LOS compared to patients who received open repair.**

EVAR was also found to be significantly less expensive for hospitals than open repair. **MRG’s analysis shows that EVAR saves an average of $9,900 per ruptured aneurysm, and $11,600 per unruptured aneurysm compared to open repair.** Much of this savings is derived from the significant reduction in LOS associated with EVAR. By treating appropriately-selected AAA patients using EVAR, **Canadian hospitals could save a substantial amount of money.** This choice would also increase access to care by reducing the average patient LOS and freeing up hospital beds so that more Canadians can receive medical treatment.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Endovascular Repair</th>
<th>EVAR</th>
<th>Open Repair</th>
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<tbody>
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<td>Complication rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruptured Aneurysm</td>
<td>59.2%</td>
<td>77.7%</td>
<td></td>
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<tr>
<td>Unruptured Aneurysm</td>
<td>17.7%</td>
<td>51.5%</td>
<td></td>
</tr>
<tr>
<td>Mortality rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruptured Aneurysm</td>
<td>24.8%</td>
<td>38.6%</td>
<td></td>
</tr>
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<td>Unruptured Aneurysm</td>
<td>1.3%</td>
<td>7.3%</td>
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<tr>
<td>LOS (days)</td>
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<td></td>
<td></td>
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<tr>
<td>Ruptured Aneurysm</td>
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<td>Unruptured Aneurysm</td>
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<td></td>
</tr>
<tr>
<td>Cost</td>
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<tr>
<td>Ruptured Aneurysm</td>
<td>$39,600</td>
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<tr>
<td>Unruptured Aneurysm</td>
<td>$27,400</td>
<td>$38,900</td>
<td></td>
</tr>
</tbody>
</table>

Note: numbers reflect rounding.
Source: Millennium Research Group

**BACKGROUND**

**AAA TREATMENT**

AAA rupture is a very serious condition with a high mortality rate. Early detection of unruptured AAA is challenging, because AAAs are often asymptomatic. Prevalence of the disease increases significantly with age, and is more common in men. Many countries in the G7—notably the UK and US—have initiated AAA screening programs directed at men aged 65 and over in order to allow for early treatment before rupture.
AAAs can be treated by minimally-invasive EVAR techniques, or by traditional open repair using a synthetic surgical graft. EVAR is quickly becoming the standard of care for AAA in the G7 countries, driven by excellent clinical and patient-centered outcomes.

In the US, ACC/AHA guidelines recommend EVAR with the highest level of clinical support. Similarly, NHS guidelines in the UK recommend EVAR as a first-line treatment of unruptured aneurysms for appropriately-selected patients. Favourable guidelines towards EVAR are the result of advancements in aortic stent graft technology that have both improved EVAR outcomes and expanded the population of AAA patients eligible for EVAR treatment.

STATE OF EVAR IN CANADA

In 2013, EVAR accounted for the majority of abdominal aortic repairs performed in the US and in Europe, but remains below 50% of total AAA repairs in Canada and Japan, as displayed in Figure 3.

Figure 3: EVAR penetration, 2011 and 2016

In Canada, global budget funding—as opposed to DRG-based funding in other G7 countries—creates a barrier to EVAR adoption (see page 2 for more detail on funding). This is the major reason that Canada’s use of EVAR lags behind the G7 average. DRG funding allows US and European hospitals to recognize the cost savings associated with EVAR relative to open repair. Conversely, global hospital operating budgets in Canada do not promote the adoption of procedures that save money through a reduced LOS. Because the savings are difficult to recognize, it is important that Canadian hospitals are aware that EVAR saves money and allows more patients to be treated.

CONCLUSION AND RECOMMENDATIONS

EVAR should be considered the preferred treatment for suitable AAA patients, as outlined by the ACC/AHA guidelines. Canada lags behind the G7 countries in adoption of EVAR relative to open repair, meaning that there is room for expansion within the recommended indications. Increased adoption of EVAR will allow more Canadians to benefit from the advantages offered by minimally invasive procedures, while saving money for
the Canadian health care system. MRG calculates that EVAR is an average of $10,000 less expensive per procedure than open repair. Efforts should be made to increase Canadian adoption of EVAR relative to open repair to the average of US, Europe and Japanese adoption. **MRG estimates that this additional cohort of endovascular patients would cost a total of $6 million less** compared to its cost using surgical techniques.

**INTERVENTIONAL ONCOLOGY SUMMARY**

**ANALYSIS AND KEY FINDINGS**

MRG conducted an analysis of US patient billing records for patients treated for HCC using either percutaneous ablation or surgical resection. **Patients receiving percutaneous ablation treatment were shown to fare better on procedural outcomes such as mortality rate, complication rate and LOS compared to patients undergoing surgical resection.**

Ablation is an especially attractive first-line option because it is significantly less expensive than resection. **MRG’s analysis shows that ablation for the treatment of HCC saves an average of $15,000 per patient compared to surgical resection.** By choosing ablation as a first-line treatment where appropriate, **Canadian hospitals could save a substantial amount of money.** This choice would also increase access to care by reducing the average patient LOS and freeing up hospital beds so that more Canadians can be treated.

**Table 4: Comparison of Percutaneous Ablation and Surgical Resection for Treatment of HCC**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percutaneous Ablation</th>
<th>Resection</th>
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<tbody>
<tr>
<td>Complication rate</td>
<td>1.5%</td>
<td>19.8%</td>
</tr>
<tr>
<td>LOS (days)</td>
<td>1.2</td>
<td>7.9</td>
</tr>
<tr>
<td>Cost</td>
<td>$11,600</td>
<td>$26,500</td>
</tr>
</tbody>
</table>

Note: Numbers reflect rounding. Source: Millennium Research Group

**BACKGROUND**

**HCC TREATMENT**

HCC is increasing in prevalence globally, and is expected to affect nearly 10,000 Canadians by 2015\(^1\). The disease is associated with a very high mortality rate, so early detection and **availability of a full range of appropriate treatment options will be critical in managing the impact of HCC in Canada.**

Minimally-invasive techniques performed by interventional radiologists can be used to treat various stages of HCC. These techniques include percutaneous tumor ablation, percutaneous ethanol injection and intra-arterial therapies such as transarterial chemoembolization (TACE) and radioembolization. The appropriate therapy is often predicated by the type and stage of the tumor that is being treated. These therapies are also commonly used in the treatment of metastatic CRC, and various other forms of cancer; please refer to “Interventional Oncology” section of Appendix 1 for more detail.
For early-stage HCC tumors, both percutaneous radiofrequency (RF) ablation and surgical liver resection are accepted treatment options. Randomized control trial data shows similar long-term results following both treatments in HCC patients with small tumours that are not widespread.\textsuperscript{12,13} This data led the Canadian HCC Consensus panel to recommend RF ablation as a first-line treatment for patients with Stage A HCC, provided that they are not candidates for liver transplantation.\textsuperscript{14} Because patient outcomes are comparable between the two treatments, it is appropriate to explore the procedural and cost benefits associated with RF ablation.

**STATE OF PERCUTANEOUS RF ABLATION IN CANADA**

RF ablation has experienced significant adoption for the treatment of HCC in the US. The American Association for the Study of Liver Disease staging system for HCC is commonly used in the US. The recommended use of RF ablation using this system is very similar to recommendations from the Canadian HCC Consensus panel. Despite comparable guidelines, Canadian interventional radiologists interviewed by MRG have expressed that it is often difficult to initiate, fund and support ablation programs with equipment, disposable catheters and clinical support. These programs are often blocked or curtailed due to funding challenges. This problem is not experienced in the US, where ablation is more widely available as a treatment option.

*Percutaneous RF ablation adoption relative to resection is approximately 30% in the US for all liver cancer. Conversely, percutaneous RF ablation adoption is less than 10% in Canada for all liver cancer. Canada lags behind the US in adoption of RF ablation, meaning that there is room for substantial expansion within the recommended indications. Increased availability of RF ablation will allow more Canadians to benefit from the advantages offered by the minimally invasive treatment, while saving money to the Canadian health care system.*
**VASCULAR ACCESS**

**BACKGROUND**

Vascular access devices are used to administer antibiotics, parenteral nutrition, and intravenous chemotherapy, as well as for transfusions and hemodialysis. Increased prevalence of chronic diseases—including diabetes, cancer, and chronic kidney disease—is driving increased requirements for vascular access device placement.

Insertion of vascular access devices can be performed either surgically in the operating room or radiologically in the IR suite. Surgical procedures are often performed “blindly” with puncture sites based on anatomical landmarks, although image guidance is becoming more common. Radiologic placement is performed by interventional radiologists, who use image guidance with ultrasonography and fluoroscopy to guide vascular access and catheter placement. This visualization contributes to documented higher technical success rates, shorter procedural times and lower incidence of procedural related complications and re-intervention rates compared to surgical insertion techniques (see Table 5). Procedure related complications that IR insertion has been shown to reduce include pneumothorax, hemothorax, arterial puncture, air embolism, nerve injury, arrhythmia, and catheter malposition. Based on these benefits, an increasing proportion of vascular access devices are being placed in the IR lab rather than the operating room.

**Table 5: Comparison of IR and surgically placed long-term vascular access devices, patient outcomes**

<table>
<thead>
<tr>
<th>Study</th>
<th>Insertion method</th>
<th>Vascular access device</th>
<th>N</th>
<th>Complication rate</th>
<th>Removal rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcy 2005</td>
<td>IR</td>
<td>Port</td>
<td>100</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>Port</td>
<td>100</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>Hancock-Howard 2010</td>
<td>IR</td>
<td>Port</td>
<td>30</td>
<td>6.7%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>Port</td>
<td>30</td>
<td>26.7%</td>
<td></td>
</tr>
<tr>
<td>Basford 2003</td>
<td>IR</td>
<td>CVC</td>
<td>41</td>
<td>31.7%</td>
<td>29.3%</td>
</tr>
<tr>
<td></td>
<td>Surgical</td>
<td>CVC</td>
<td>57</td>
<td>52.6%</td>
<td>45.6%</td>
</tr>
</tbody>
</table>

Source: Millennium Research Group

**CONCLUSION AND RECOMMENDATIONS**

IR placement of vascular access devices is a well-established practice in Canada as well as the rest of the G7 countries, and has become the standard of care.

IR placement is cost effective compared to surgical placement because it is quicker, requires fewer resources, and results in fewer complications and device removals. The reduced need for follow-up procedures following IR placement results in more efficient resource management.

MRG recommends that increased funding and support be made available to IR practices in Canada to enable interventional radiologists to meet growing requirements for vascular access devices placement and management of complications, while working to expand into other procedure types, as advocated elsewhere within this document.
EMERGENCY EMBOLIZATION

BACKGROUND

Severe life threatening bleeding can occur in many different clinical situations including trauma, gastrointestinal hemorrhage, hemoptysis (bleeding from the lungs from chronic lung diseases such as cystic fibrosis), post-surgical bleeding and tumor-related hemorrhage.

Definitive therapy to control bleeding is required when conservative measures fail, however surgery often involves a high risk due to the poor general condition of the patient, and the high morbidity and mortality associated with a major surgical procedure. Interventional radiologists can perform emergency embolization in these situations as a low risk, minimally invasive alternative to surgery. This lifesaving procedure allows definitive treatment by blocking the arteries that are the source of the bleeding.

In many instances, embolization is the only option available for a patient. As a result of the high efficacy in controlling bleeding with minimal risk, embolization has become the gold standard for the treatment of pelvic bleeding. It is also the treatment of choice for most internal hemorrhage because it can be performed anywhere in the body. Emergency embolization is also established in trauma-related and internal bleeding treatment pathways that cross multiple specialties. The skill required to perform this procedure is high, and remains specialized within the interventional radiology field.

CONCLUSION AND RECOMMENDATIONS

Effective treatment of this challenging patient population requires a multidisciplinary approach that recognizes the tremendous value of embolization to treat severe bleeding from trauma or other sources. The catheter skill required of interventional radiologists is a clear demonstration of the value that this physician group contributes to a multidisciplinary team. MRG recommends that IR programs be supported beyond specialized centers so that this critical procedure can be made widely available to all patients.
Figure 6: Percutaneous Emergency Embolization Procedures, per capita (millions), 2011 and 2016

Source: Millennium Research Group

DRAINAGE

BACKGROUND
Image guided drainage procedures fall into two categories: drainage of obstructed organs (usually the kidneys or liver), or of abnormal fluid collections (usually abscesses). Simple drainages are carried out by both diagnostic and interventional radiologists while more complex drainages are performed by interventional radiologists only.

PERCUTANEOUS ABSCESS DRAINAGE
Abdominal abscesses often occur following surgery. “Over the past twenty years, percutaneous abscess drainage has evolved from revolutionary to routine, replacing open surgical drainage in all but the most difficult or inaccessible cases.”

Imaging guided percutaneous drainage has been shown to be as effective as open surgical drainage, with reductions in complication rates, LOS and overall costs. Success rates of up to 90% are common. Even if drainage is incomplete, percutaneous abscess drainage often allows surgical treatment to be carried out electively instead of emergently, which decreases the overall risks for the patient.

PERCUTANEOUS NEPHROSTOMY AND BILIARY DRAINAGE
Percutaneous drainage techniques are also utilized to drain obstructed organs, particularly the kidneys (nephrostomy) and bile ducts of the liver (biliary drainage). Obstruction of these organs may occur from tumours or from benign causes such as stones or previous inflammation with scarring. Alternative therapies are drainage through an endoscope or via open surgery. Endoscopic drainage of obstructed kidneys and bile ducts are frequently carried out, with similar effectiveness and complication rates as percutaneous drainage. However, the success rates of percutaneous drainage tends to be higher than that of endoscopic drainage and the overall costs are lower for percutaneous drainage. Currently, open surgery is rarely used to treat kidney and bile duct obstructions.
CONCLUSION AND RECOMMENDATIONS
Percutaneous image guided procedures have largely replaced more invasive techniques of treating abdominal abscesses and other fluid collections, and have had a major impact on the treatment of biliary and renal obstruction. These IR techniques have been shown to be safe and cost effective. Their use has decreased the need for other resources such as OR time and inpatient beds.

Abscess drainage in particular is a procedure that underscores the value of IR. The pervasiveness of abscess drainage has lessened the burden of abscesses as a complication to surgery, with many surgeons considering abscesses to be a negligible risk to surgery. IR’s role in lessening the burden of abscesses has allowed many different types of surgery to expand, thus improving overall patient care.

An aging population means an increasing number of patients will require drainage treatment. Adequate provision of resources to IR will be necessary to improve and maintain access to percutaneous drainage procedures in the future.

GASTROSTOMY

ANALYSIS AND KEY FINDINGS
The safety associated with percutaneous radiologic gastrostomy (PRG) is well documented. It has been shown to lead to lower complication rates compared to surgery or percutaneous endoscopic gastrostomy (PEG), while maintaining similar or superior success rates (see Table 6). Furthermore, a Canadian study demonstrated that PRG is less expensive than PEG, with PEGs costing 44% more than PRGs.

| Table 6: Comparison of radiologic, endoscopic, and surgical gastrostomy, patient outcomes |
|---------------------------------|--------|----------|-----------|
| Insertion method | N      | Success Rate | Complication rate |
| PRG              | 837    | 99.2%      | 5.9%       |
| PEG              | 4,194  | 95.7%      | 9.4%       |
| Surgery          | 721    | 19.9%      |            |


BACKGROUND
Gastrostomy is an essential procedure for patients who cannot ingest food orally due to anatomical restrictions or conditions such as stroke, cerebral palsy and brain injury. Placement of tubes can be done by surgical, endoscopic (PEG) or radiologic (PRG) means. PEG is the most common form of gastrostomy, while PRG is the least common form, accounting for approximately 20% of gastrostomy procedures in Canada (see Figure 7). PRG is typically used in situations where gastric access via the naso-oral route is challenging because of tumour presence or other obstructions, making PEG difficult to perform.

CONCLUSION AND RECOMMENDATIONS
MRG recommends that PRG should play a larger role in Canadian hospitals, due to the cost effectiveness and safety that have been demonstrated using this technique. Increased adoption of PRG relative to PEG would save money to Canadian hospitals, while freeing up space in the endoscopy suite and OR for other procedures.
UTERINE FIBROID EMBOLIZATION (UFE)

BACKGROUND

Uterine fibroids are benign muscular tumours that can cause symptoms such as pain and infertility, and are one of the most common gynaecological conditions. This condition can be treated surgically, via hysterectomy and myomectomy (performed by gynaecologists), or by minimally invasive UFE, performed by interventional radiologists. There have been multiple large registries and randomized trials that validate UFE as an equally effective treatment for uterine fibroids, on par with the surgical alternatives. The American College of Obstetrician and Gynaecologists recommends UFE as a level A treatment option for uterine fibroids, and describes the procedure as "safe and effective.

UFE is minimally invasive with less major complications, faster recovery and improved patient satisfaction compared to surgical intervention. There is no periprocedural blood loss in UFE. General anesthesia and surgical incisions are avoided, and the recovery is generally around one week (compared to 6-8 weeks after surgery). This has a cost benefit to the health care system and society, with women admitted to hospital for a shorter duration (if at all) and returning to work faster. The cost effectiveness of UFE has been demonstrated in many G7 countries, including a Canadian study that demonstrated that UFE is associated with a lower hospital cost and a shorter hospital stay compared to myomectomy and hysterectomy.

Despite this, the global adoption of UFE is limited by lack of awareness by patients and family physicians. It has been reported that many gynecologists do not inform patients of UFE as a treatment option. As a result, hysterectomy is still the most common treatment for uterine fibroids, and is performed disproportionately in comparison to UFE, despite the strong evidence supporting embolization.

CONCLUSION AND RECOMMENDATIONS

UFE is a very safe and effective procedure with low risk of complications and fast recovery that results in decreased costs to the health care system. It is very important that Canadian patients are made aware of all
options available before treatment is selected. **MRG recommends that CIRA work with gynaecologists, family physicians and uterine fibroid support groups to run patient awareness programs.** This will help Canadian women make informed choices about their uterine fibroid treatment.

Figure 8: UFE Procedures per capita (millions), 2011 and 2016

Source: Millennium Research Group

**HEMODIALYSIS ACCESS MAINTENANCE**

**BACKGROUND**

The volume of patients requiring hemodialysis represents a significant burden to the healthcare system. Approximately 400,000 end-stage renal disease (ESRD) patients undergo dialysis every year in the US alone, and the prevalence of ESRD is increasing at a rate of about 3% per year.\(^6\)

Hemodialysis access is achieved through an arteriovenous (AV) fistula or a synthetic surgical graft. Fistulas and grafts are prone to plaque buildup and thrombosis, and must be maintained through angioplasty and clot management to ensure a healthy access site. Access sites may also require aneurysm treatment using stent grafts placement or embolization of collateral vessels. The variety of interventions required to maintain hemodialysis access site health necessitates a collaborative effort among nephrologists, vascular surgeons, and interventional radiologists. Optimal integration of the interventional radiologist is crucial in the success of a hemodialysis program. Although the majority of maintenance procedures are angioplasties that can be performed by many physician types, **interventional radiologists are the only physician group that performs all types of interventions that may be necessary for hemodialysis access management.**

In addition to angioplasty, interventional radiologists perform clot management procedures, stent graft placement, collateral vessel embolization, and make clinical diagnoses for each procedure. Because interventional radiologists perform all of these interventions, this physician group is in a good position to assess the needs of hemodialysis patients and make broad treatment decisions.
CONCLUSION AND RECOMMENDATIONS
Effective treatment of the dialysis patient population requires a multidisciplinary approach that combines endovascular and surgical interventions. Communication and coordination of the treatment strategies among all disciplines is needed to achieve optimal results. MRG recommends that interventional radiologists be an integral part of the multidisciplinary care team for Canadian hemodialysis patients. This would help streamline care of hemodialysis patients, and ensure that these patients receive optimal treatment.

CAROTID ARTERY STENTING

BACKGROUND
Carotid artery disease occurs when the degree of atherosclerosis in the carotid arteries disrupts blood flow. Carotid artery disease is associated with an increased risk of both ischemic and haemorrhagic stroke. The majority of carotid stenoses are mild or asymptomatic and are treated using aspirin and stroke-preventing statins such as Lipitor. More severe disease may be treated by surgical carotid endarterectomy (CEA) or endovascular carotid artery stenting (CAS). Studies have demonstrated similar efficacy for both CEA and CAS, however CAS is associated with a higher risk of stroke. Due to the elevated stroke risk, CAS is typically reserved for high-risk symptomatic carotid artery disease patients. Accordingly, CAS volumes are quite low throughout the G7 countries. CAS is not expected to experience more than low single digit growth or to see significant use beyond its current indications unless stronger clinical evidence emerges showing superior outcomes for CAS relative to CEA. Further limiting the current potential for CAS is the fact that the procedure requires a high level of procedural competency that is relatively difficult to obtain because most physicians do not perform a sufficient volume of CAS procedures.

CONCLUSION AND RECOMMENDATIONS
CAS will continue to play a vital role in the treatment of symptomatic high-risk carotid artery disease. However, because CAS is a technically challenging, low-volume procedure with serious associated risks, only very skilled and experienced physicians should perform the procedure. In the Canadian context, CAS should be performed exclusively by physicians with a high level of endovascular training and significant experience specific to carotid artery disease management. Interventional radiologists are the ideal treating physician for this procedure because this specialty group has the catheter expertise required to minimize complications. The strong catheter skills of interventional radiologists are evidenced by this specialty’s success in extremely technically-challenging emergency embolization procedures, as described below (see page 16).
Thoracic endovascular aortic repair (TEVAR) is a safe procedure that reduces the perioperative risks of thoracic intervention compared to surgical repair. TEVAR also offers shorter patient recovery times. By addressing an unmet need in thoracic artery repair, TEVAR has been strongly embraced in the G7 countries.

Adoption of TEVAR relative to open repair is not as strong as that of EVAR in most countries because there is a substantial portion of the patient population that cannot be treated using the currently available thoracic devices. Future improvements to thoracic aortic stent grafts—including branched grafts—will drive continued TEVAR adoption in the G7 countries.

TEVAR is extremely underpenetrated in Canada compared to the rates of endovascular repair in the G7 countries. TEVAR penetration relative to open repair is 45% or higher in all G7 countries, but only accounts for approximately 15% of thoracic procedures in Canada, as displayed in Figure 10.
As with EVAR, TEVAR is hindered in Canada by the unique way that healthcare budgets are allocated, as described in above the Canadian health care funding section (see page 2).

**CONCLUSION AND RECOMMENDATIONS**

TEVAR rates in Canada are low relative to global adoption of the procedure. Open thoracic procedures are extremely invasive, technically difficult, and carry high procedural risks. TEVAR has been widely adopted in the G7 countries because it is a safe and effective alternative to surgery. **Efforts should be made to raise the use of TEVAR to closer to 50% of total thoracic artery repair procedures.**

**FINAL REMARKS**

MRG’s analysis has concluded that IR adds value to a wide variety of therapy areas and patient populations. Canada lags behind other countries in the G7 in the adoption of patient-friendly, cost saving and lifesaving IR treatment. The lower-than-average adoption of IR in Canada is problematic for the Canadian health care system, because IR has been shown to reduce patient hospital stays, reduce the need for follow up, and reduce patient costs. MRG concludes that Canadian government and health care facilities should make efforts to take advantage of IR’s value in order to reduce financial strain and improve patient care.
Interventional Radiology

multivariate analysis of 400 patients.

AJR American Journal of Roentgenology

Analysis of 1254 Port Implantations at a Single Center.

venous port systems.

Radiologic versus conventional operating room methods in pediatric patients with cancer.

or radiologically in pediatric oncology patients.

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