The promise of real-time detection and response to life-crippling diseases brought by the Implantable Internet of Medical Things (IIoMT) has recently spurred substantial advances in implantable technologies. Yet, existing medical devices do not provide at once the miniaturized end-to-end body monitoring, wireless communication and remote powering capabilities to implement IIoMT applications. This paper fills the existing research gap by presenting U-Verse, the first FDA-compliant rechargeable IIoMT platform packing sensing, computation, communication, and recharging circuits into a penny-scale platform. Extensive experimental evaluation indicates that U-Verse (i) can be wirelessly recharged and can store energy several orders of magnitude more than state-of-the-art capacity in tens of minutes; (ii) with one single charge, it can operate from few hours to several days. Finally, U-Verse is demonstrated through (i) a closed-loop application that sends data via ultrasounds through real porcine meat; and (ii) a real-time reconfigurable pacemaker.