Let $G$ be a complex connected semisimple group of adjoint type with Lie algebra $\mathfrak{g}$. Fix a Borel subgroup $B$ of $G$ with Lie algebra $\mathfrak{b}$ and nilradical $\mathfrak{n} \subset \mathfrak{b}$. The main result of the paper under review is the equivalence of certain derived categories associated to these data. The intermediate category is the bounded derived category $D^{b}\text{Coh}^{G \times \mathbb{C}^{*}}(\tilde{\mathcal{N}})$ of $G \times \mathbb{C}^{*}$-equivariant coherent sheaves on the Springer resolution $\tilde{\mathcal{N}} = G \times_{B} \mathfrak{n}$ of the singularities of the nilpotent cone $\mathcal{N}$ of $\mathfrak{g}$. It is shown that $D^{b}\text{Coh}^{G \times \mathbb{C}^{*}}(\tilde{\mathcal{N}})$ is equivalent (as a triangulated category) to the mixed version of the derived category $D^{b}\text{block}^{\text{mix}}(U)$ of finite-dimensional modules in the principal block of the quantized enveloping algebra $U$ at an odd root of unity of order prime to 3. Moreover, $D^{b}\text{Coh}^{G \times \mathbb{C}^{*}}(\tilde{\mathcal{N}})$ is also equivalent (as a triangulated category) to the derived category $D^{b}\text{Perv}^{\text{mix}}(\text{Gr})$ of mixed $\ell$-adic perverse sheaves on the loop Grassmannian $\text{Gr}$ of the Langlands dual of $G$ which are constructible with respect to the standard stratification of $\text{Gr}$. Furthermore, the authors show that the composite equivalence from $D^{b}\text{block}^{\text{mix}}(U)$ to $D^{b}\text{Perv}^{\text{mix}}(\text{Gr})$ is compatible with the natural $t$-structures on these categories and therefore induces an equivalence of the non-mixed abelian categories $\text{block}(U)$ and $\text{Perv}(\text{Gr})$. This equivalence yields a proof of a conjecture due to the third author and S. Kumar [Duke Math. J. 69, No. 1, 179-198 (1993; Zbl. 0774.17013)] relating quantum group cohomology to perverse sheaves on the loop Grassmannian and also provides character formulas for simple modules in the principal block of $U$ in terms of intersection homology sheaves on the loop Grassmannian as conjectured by G. Lusztig [Geom. Dedicata 35, No. 1-3, 89-114 (1990; Zbl. 0714.17013)].